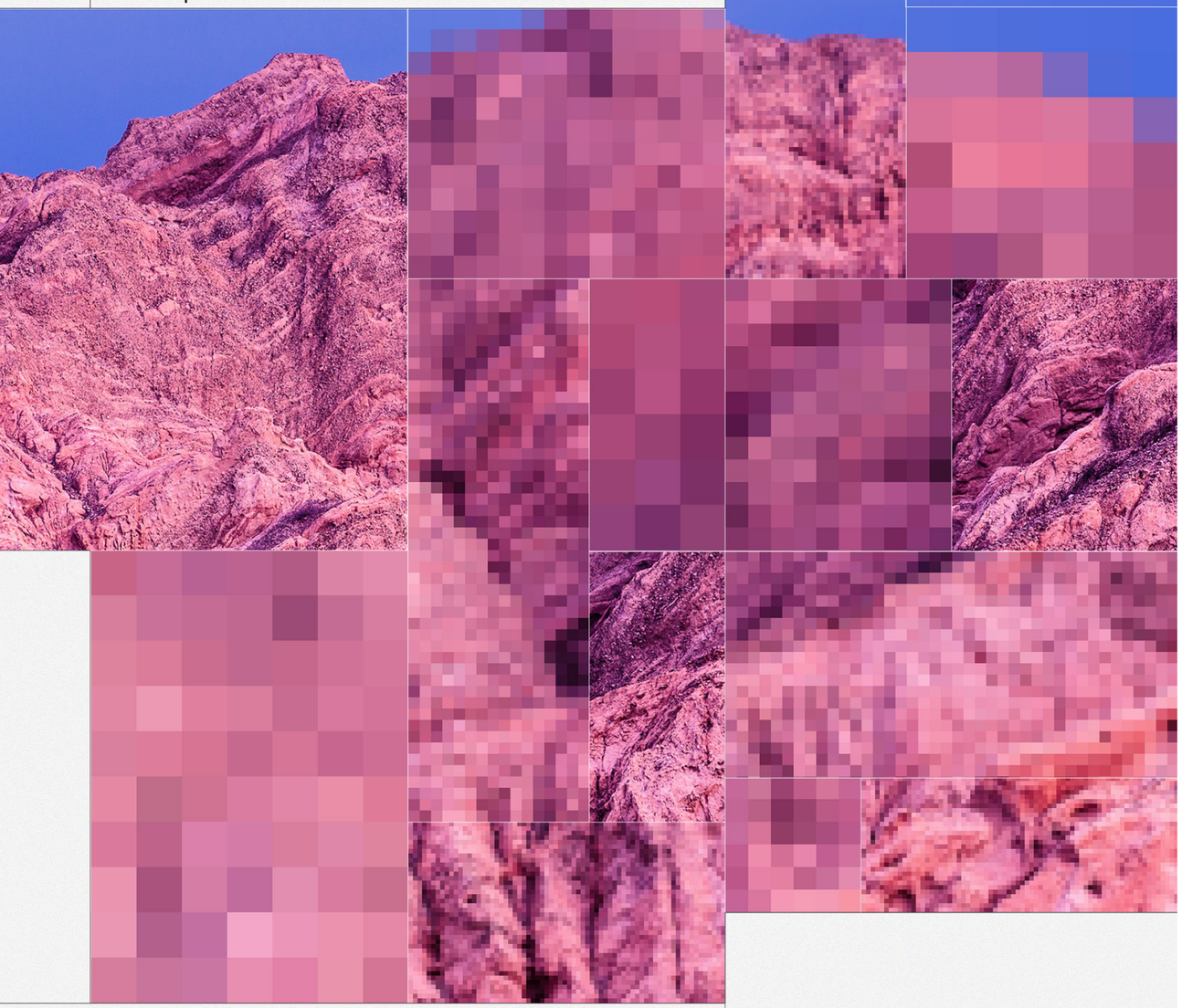
Future of AI in Latinamerica

Chapter **F**



F.1
Main Findings

Prioritize investment in connectivity and computing capacity in the region.
It is urgent that the region invests in reducing gaps in connectivity and access to specialized computing, without relying on corporations from the Global North. In particular, there is a need to strengthen access to high-speed internet in order to avoid increasing structural inequalities and to enable effective implementation of AI.

Strengthen education systems comprehensively as a matter of urgency.
A solid and continuous educational approach is essential to meet the challenges posed by AI, from the initial stage to the mechanisms for job retraining. This strategy is key not only to address automation, but also to combat the talent drain, boost R&D and innovation, and have an impact on the region's productive matrices.

Promote cross-border collaboration and generate regional data repositories.
The experts highlighted the importance of establishing multicultural collaborations between countries in order to have more complete data repositories. The diversity in the region makes it possible to develop AI systems that reflect the particularities and challenges specific to each country and reflect regional commonalities.

Strengthen regional cooperation at the governance and research levels.
The need to strengthen regional cooperation to avoid technological and regulatory colonialism was emphasized. By collaborating among countries, the region's interests are protected. To this end, the creation of multilateral institutions to coordinate and finance research on regional challenges and promote regulatory reflection in harmony with the idiosyncrasies of each country was proposed.

Urgent progress in regulating AI or critical sectors that could be affected by it.
Experts emphasize the urgent need for sound regulation to address the risks and challenges of AI before they outweigh the opportunities in the region. Data protection, transparency and multilateral governance are key and urgent. There is a need in this process to learn from the regulatory experience of the Global North without falling into mimicry.

Promote developments based on the unique characteristics of the region.
The importance of promoting AI systems based on unique characteristics was stressed. Taking advantage of the diversity of languages, biodiversity and use of renewable energies can drive innovative and sustainable projects in the field of AI and generate competitive advantages at a global level.

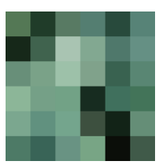
Promote the development and use of AI to address social challenges.
The importance of establishing guidelines and incentives to take advantage of the potential of AI to transform Latin American society in various ways, from improving public services to boosting innovation in different sectors, was emphasized.

There is a cross-cutting concern about the growing power of corporations.
The need to establish adequate regulatory frameworks to protect people's rights, minimize algorithmic biases and ensure transparency and accountability in the use of AI was discussed, especially given the control exercised by the corporations that develop the systems and their preponderance in the Global North.

AI can widen the gaps in the region if the structural conditions that generate them are not addressed.
The existing gaps in terms of capabilities, access to technology and financial resources in Latin America were highlighted. The experts expressed their concern about the possibility that the adoption of AI could deepen inequalities, both at the level of countries (developed vs. the rest) and at the level of individuals.

Build an institutional framework that promote collaboration between industry, the public sector and academia.
The focus groups highlighted the importance of collaboration between public, private and academic stakeholders to drive the development of AI. However, the lack of collaboration schemes, misaligned incentives, lack of funding, lack of institutionalism and distrust were discussed.

Corruption and lack of trust emerge as significant risks to ethical AI development.
Worrying institutional weakness and corruption have undermined citizen trust, which directly impacts the development of innovation ecosystems. It is critical to address these issues to foster an enabling environment that ensures the ethical and responsible use of AI in Latin America, promoting greater collaboration between different actors to overcome these challenges.

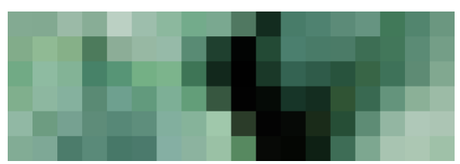


F.2
Chapter presentation

This chapter aims to analyze in depth the future projections of AI for Latin America and the Caribbean in a global context. It will seek to determine how the region can make the most of the potential of this technology within the framework of its national innovation systems. It will also examine the barriers and obstacles that may be holding back the full development of AI in the region. On the other hand, it offers an overview of the state of the art and practice in what are considered dominant trends in the discipline from the academic perspective, and proposes elements to pay attention to in the coming years, particularly from the regional context.

The methodological approach employed in the first section considers the active participation of experts and key industry players in Latin America and the combination of analytical methods for their interpretation and synthesis. This will ensure a holistic and contextualized understanding of the AI situation in the region. In the second section, a literature review was conducted and academics with experience were convened to consult the most relevant trends.

This chapter seeks to contribute to the strengthening of AI in Latin America and to encourage its active participation in future global reports. The findings identified in the participatory spaces as well as in the reflection of academics regarding relevant scientific trends reflect that the global challenges of AI are similar to those identified for the region, but that they acquire certain particular elements when analyzed from a local perspective. Developing systems based on unique data, building multilateral governance and regulation schemes, or investing in connectivity and infrastructure to reduce gaps, are some of the global challenges that must be addressed considering the regional context.



F.3
Methodology and results

For the preparation of this chapter, the areas where AI could have the most significant impact in the Latin American context were identified. Six specific areas were defined:

A. Education
B. Health
C. Citizen participation and democracy
D. Climate change and biodiversity
E. Automation
F. Academic research

These topics were defined through consultations with key informants from the public and private sectors, academia and international organizations in Latin America, and were identified as those with the greatest potential impact of AI on social life.

For each specific topic, a group of experts was convened to participate in a focus group, where they discussed future scenarios, optimistic and pessimistic, the elements that will condition the achievement of each scenario, and the role of Latin America in the global AI landscape.

The focus groups were attended by experts from Bolivia, Chile, Colombia, Mexico, Argentina, Brazil, Costa Rica and Uruguay. The diversity of countries present in the discussion allowed for a regional approach, which, taking into account the specific experiences and contexts of each participant, provides an overview of the challenges outlined below.

A. Education

An optimistic scenario regarding the personalization of learning was addressed. Possibilities were explored to enhance the development of skills and the change from the role of teachers to that of mentors and companions in the learning experience of students. They also discussed the potential of new tools to enable more global education, such as instant translation, and how this could improve access.

On the other hand, experts expressed concern about how personalization and the use of technology could impact the socioemotional development of children. This could lead to a reduction in the space for contextualization of learning and an exacerbation of individuality over the social aspect. In addition, concern was raised about a possible decrease in interest in teaching careers due to the automation of certain processes, which in the long term could deepen inequality by limiting access to technology and exacerbating social gaps.

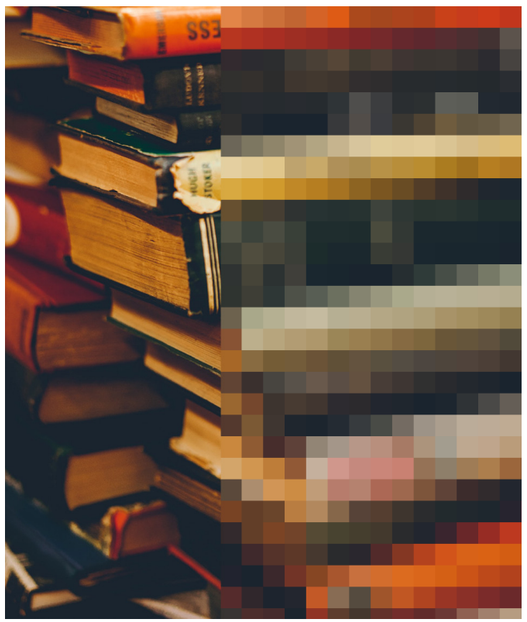
One of the challenges raised was the need for highly trained teachers to use technology effectively and guide students in its use. This is related to the importance of enhancing minimum and cross-cutting skills to foster an adequate appropriation of technological systems. In the context of Latin America, this challenge is especially acute due to the existing teacher gap, particularly in areas related to technology. The need to establish mechanisms that would allow the region not to depend exclusively on developed countries was also raised, in order to avoid new forms of technological colonialism.

In relation to the above, the role of teachers was discussed as going beyond the teaching of content. It was emphasized that educators must adapt to assume a more social role, based on the physical and palpable experience of the world. This implies the need to develop digital skills in teachers and promote critical thinking and ethical aspects related to technology, which will require changes in teacher training curricula.

One of the most pressing challenges identified was the democratization of access to basic enabling factors such as connectivity and computing capacity. Mention was made of countries in Latin America where educational establishments lack Internet access or even electricity, which prevents them from taking advantage of the benefits of AI. Along the same lines, it was noted that the social capital of families has an impact on the ability to adopt these technologies, which could aggravate structural problems in Latin American societies.

In terms of opportunities, emphasis was placed on the richness and cultural diversity of Latin America, as well as the common language spoken in most of the continent. This could be a distinctive element for training systems and developing a vision of AI in education on a regional scale. The possibility of developing classroom monitoring and control tools to support the work of teachers was also raised. In addition, tools were considered to automate processes such as evaluations, which would free up teachers' time for these types of activities.

Finally, a reflection was made on how the way in which education and technology are thought of should change. A vision was proposed where education integrates and guides the appropriate use of technology. This implies a call to think holistically about how to incorporate the new systems into educational circuits, which vary significantly according to household income and resources, as well as between rural and urban contexts, the hierarchies present in establishments and the different educational philosophies. The importance of adapting technology to strengthen learning processes, promote equity and enrich the educational experience, while respecting the diversity and particularities of each educational environment, is highlighted.



B. Healthcare

An optimistic scenario was discussed in which the combination of nanotechnology and artificial intelligence would generate a highly effective artificial immune system to fight diseases, especially cancer. The possibility of personalized medicine, which constantly monitors vital data to prevent health problems, and the incorporation of high-precision robots in medical treatments were also explored. The prospect of improving cognitive abilities through AI systems was also discussed.

On the other hand, concern was raised about a growing inequality in which access to these systems could determine different levels of capability in people. This inequality would not only be linked to socioeconomic issues, but also to the representation of various groups in the data used to train AI systems. In addition, the possibility that automation in screening and the replacement of physicians as the first contact in health care could generate fear in the population and resistance among health professionals was mentioned.

Relevant advances in the coming years were considered, such as high-precision robotic surgery, the use of AI in the design of new drugs (both personalized and generic) and augmented and virtual reality integrated with AI systems for training, procedures and support in medical diagnosis, although none of these developments were specifically associated with the Latin American region. Therefore, the challenge arose to not only be consumers of technology, but to look for unique opportunities where Latin America can contribute more than just adapting existing technologies.

From this, the opportunity that exists in Latin America to train models in other languages and cultural contexts was addressed. In addition, the region has specific and little studied diseases (such as Chikungunya) that could contribute to the development of more robust systems. There are also common elements in terms of diet and prevalent diseases that could facilitate the adaptation and development of AI health systems specific to the region.

Relevant barriers were identified, including the possible rejection of some health professionals towards the implementation of AI systems, especially in initial screening and primary care roles. However, it was analyzed that, given the lack of health professionals in the region, the proper implementation of AI systems could become an opportunity to improve care capacity.

At the administrative and financial level, the importance of establishing governance and institutional frameworks that protect the data of individuals, but also encourage innovation in the

field of health in Latin America, was noted. There is a significant deficit in financial resources for research and development, compared to developed countries. In addition, the need to improve collaboration models between industry and academia in the region was raised.

The possible negative impact on the development of AI systems in healthcare specific to Latin America was highlighted. Models based on data predominantly from the Global North could underperform in regions of the Global South, such as Latin America, where different diseases, climates and socioeconomic conditions exist. Therefore, the adaptation or development of local models presents itself as an important opportunity that, with adequate resources, should be encouraged in the region.

In line with the above, the need to establish collaborative networks at the regional level between academia, the public sector and industry in the field of health was emphasized. Initiatives were mentioned that promote cross-cultural studies and advance the digitization of health data, both nationally and regionally, to improve access to and exchange of relevant information in the field of artificial intelligence applied to health in Latin America.

C. Civic participation

An optimistic scenario was discussed in which government systems and public policies would become more evidence-based, which could lead to a more informed and engaged citizenry in decision making.

In addition, elements were discussed that participants could not clearly classify as positive or negative. One such element was the automation of decisions through, rather than relying solely on, human decisions. This could mean the end of representative democracy as we know it, giving way to structures based on citizen-generated data.

This possibility presents the potential to distribute power among citizens and move towards more direct models, but also poses the challenge of ensuring that AI systems do not substitute for human will and that behavioral data is not used in a manipulative way. Given this, it was felt that if processes do not advance in the field of transparency and explanation, they could become increasingly opaque, which would eliminate any possibility of accountability on the part of the State towards citizens.

On the other hand, concern was expressed about the dominance of large corporations and a data-centric philosophy. This could put into question individuals or groups that do not generate the expected data and result in mechanisms of control and exclusion disguised as technical and mathematical objectivity.

Given this, the need to advance in regulations both for AI systems and for the protection of personal data, cybersecurity and public procurement, among other relevant areas, was discussed. However, the power of corporations and the influence of regulations from developed countries was recognized. This could put pressure on Latin America to adopt regulatory frameworks that do not fit its socio-cultural characteristics. To counteract this risk of excessive technological and regulatory colonialism, the importance of greater regional collaboration and the strengthening of institutional frameworks was highlighted.

One proposed strengthening mechanism along these lines is that AI systems can be used to improve transparency and accountability to citizens. If applied ethically and responsibly, these systems can become tools to combat corruption, increase trust in government institutions and promote participation and understanding of political processes.

The development of capacities and knowledge in the public apparatus to acquire and/or develop AI systems was identified as a challenge both globally and regionally. Although there are successful initiatives in the region, such as the Ethical, Responsible and Transparent Algorithms Project in Chile or the strategy of the Agency for Electronic Government and the Information and Knowledge Society in Uruguay, the need to strengthen the institutional and regulatory framework to meet this challenge was underscored.

Specifically in the area of citizen participation, it was noted that AI systems can contribute not only to the processing of large volumes of qualitative information, but also to providing legislators and policymakers with better information on citizen positions and proposals.

D. Climate crisis

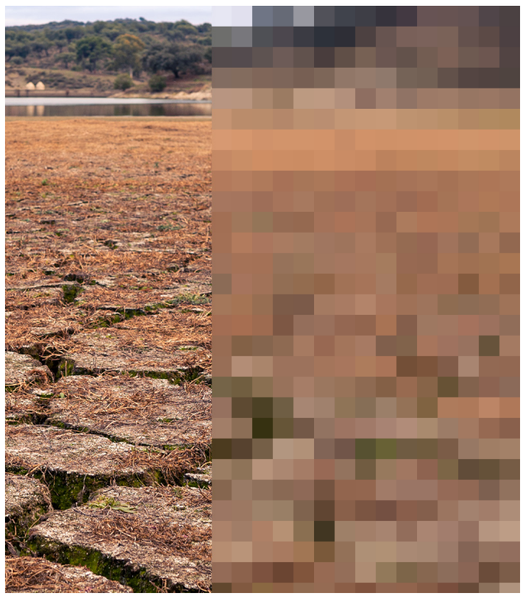
In the optimistic scenario outlined at the beginning of the discussion, AI systems make it possible to anticipate and manage natural disasters more effectively, which facilitates the development of more resilient infrastructures in the face of extreme weather events. AI also contributes to mitigating environmental impacts by promoting more efficient energy use.

On the other hand, the possibility of a progressive disconnection of humans from natural ecosystems was discussed, reducing interaction with the living environment to mere data analysis and digital systems. This could accelerate degenerative processes in ecosystems without being noticed until they become irreversible. In addition, there was a warning about over-reliance on technology and the apparent objectivity of algorithmic systems, which could increase opacity and hide biases, preventing a timely response by societies to climate threats.

Concern was highlighted about technological advances such as generative AI models, which require large amounts of energy for training, representing a global risk, but could more acutely affect countries more exposed to climate change. It was emphasized that most AI system developments are motivated primarily by economic incentives and rarely consider their impacts on the environment.

Participants noted that Latin America's culture in relation to the environment is unique and could be an opportunity for the development of technologies focused on conservation and remediation. Biodiversity and the presence of unique ecosystems, such as the sub-Antarctic region or the Amazon rainforest, could be enablers for this type of development. The challenge posed by the prevalence of extractive industries in the region and the dependence on the export of raw materials was considered, but opportunities to develop technologies to optimize these industrial processes and reduce their environmental impact were also recognized, given their importance in the region's economies.

In addition, the diversity present in Latin America was highlighted as an opportunity to develop specific technologies for different ecoregions. However, the existing obstacles in terms of funding for research and development, as well as the brain drain to the Global North, were pointed out. In addition, infrastructure gaps, such as connectivity and local computing capacity, need to be addressed to fully exploit the potential of AI in the fight against climate change in the region.



E. Automatization

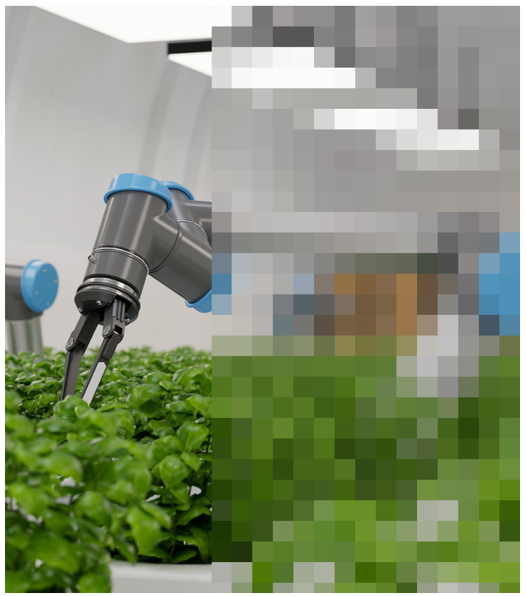
A process of automation that would free people from unwanted work, allowing them to devote themselves to work of interest to them and enjoy their leisure time, was the optimistic projection that started the reflection. An improvement in the quality of life was envisioned, driven by higher productivity and better income distribution. The ability to preserve culture and historical memory through digital technologies was also emphasized.

However, the worrying consolidation of monopolies in large corporations in developed countries could translate into a dominant control over AI tools and their applications, reaching a power greater than that of the states themselves by controlling the factors of production essential to humanity.

Furthermore, it was warned that unequal access to education could accentuate the gaps between countries and individuals in society, generating losers and winners in the automation process. It was pointed out that the historical processes of technological change have always been rapid and incomplete, and that the aspiration for greater equity and productivity could never materialize, deepening the inequalities between countries that develop technology and factors of production and those that do not. The region faces a colonial situation in AI technological development, with insufficient integration that leaves countries isolated in competition with the Global North and hinders the emergence of cutting-edge technological developments.

Education stands out as a crucial aspect at a global level to positively take advantage of process automation, and emerges with special importance for Latin America, where the quality of educational systems and the lack of policies for talent development are unavoidable gaps. Shortages of advanced human capital, talent drain and poor curricula in primary and secondary education could increase labor dependency and casualization in the context of automation.

To overcome these challenges, the countries of the region need to develop educational policies that cover everything from initial education to job retraining. However, cultural and political barriers, together with high levels of corruption and low trust, hinder a long-term vision and commitment among different sectors to improve the education system and modernize productive structures.



F. Academic research

Central to the optimistic vision is the opening up of new fields and opportunities for development and innovation in connection with industry through AI. The analytical capabilities of AI would allow scientists more time to address meaningful questions. In addition, academia could use this technology to address major societal challenges, such as climate change or public health, improving the quality of life.

On the other hand, the power to guide research would be concentrated in a few institutions with the knowledge and capabilities, which would increase the inequality between developed countries and the rest of the world. These regions could become mere sites of testing and consumption, without participating in or benefiting from development. The lack of adequate regulation would allow unethical uses, such as the creation of humans of different categories through brain-machine interfaces.

In addition, the region faces funding challenges for research and technology transfer, which impacts both the development of research and the distribution of talent. With more abundant resources in the Global North, there is a significant drain of talent to developed countries, and although some Latin American countries have implemented policies to train human capital abroad, the lack of adequate compensation mechanisms hinders the return of this talent and its full contribution at the local level.

At the global level, industry plays a preponderant role in AI research, which influences the incentives, guidelines and safeguards for advances in the discipline. Since these companies are mostly concentrated in the Global North, this exacerbates the North-South gap and leads to a loss of cultural and territorial relevance in developed technological systems.

This increases the lack of coordination between the national innovation systems of Latin American countries. The need for greater regional collaboration in AI research is highlighted, linking it to common challenges and facilitating access to funding. This articulation would allow the development of frontier research with cultural and territorial relevance within the region. In addition, coordination in the regulation of common aspects of governance could avoid negative impacts and promote more fluid collaboration in the use of data and infrastructure.

F.4
Academic trends and their impact in LAC

AI is a discipline whose applications and developments transcend the field of computer science. The capacity for inference, pattern recognition and optimization allow its use in the development of academic research in other disciplines such as the exact sciences or art; the need to understand and explain systems based on mathematical and statistical rules drives collaboration with disciplines such as mathematics, physics and logic; and the consequences in modern societies of the penetration of this technology requires a deep and permanent ethical reflection.

This chapter will address the global state of the art and the most relevant trends that are projected for the future for 5 fields of research and development associated with AI, with special emphasis on Latin America:

A. Vision and language models
B. Ethics
C. AI and exact sciences
D. Explainability
E. AI and art

The projections offered arise from the reflection of Latin American academics and reflect the expectations that exist for the development of the discipline and transdiscipline in the coming years.

A. Vision and Language models

State of art and relevance

The current revolution in AI is closely associated with the success achieved by Deep Learning (DL) techniques in visual recognition tasks, either in images or video, and in natural language processing tasks, either in written or verbal language. As an example, the turning point that starts the present revolution in AI dates back to 2012, with the success of the AlexNet convolutional network in the ImageNet visual recognition challenge. Indeed, although the initial ideas on DL arise in the 80s and 90s, mainly through the work of the 3 Turing Awards: Bengio, Hinton and LeCun, it is the success of AlexNet that massifies the popularity of these techniques.

To understand how the impact of DL on vision and language triggers the current moment of AI, it is essential to consider the evolution that information technology (IT) has undergone. At the time of AlexNet's publication, IT had reached a high level of development for storing and processing so-called structured data. This corresponds to tabular data with rows and columns with highly semantic attributes, mainly demographic and transactional data, generated through structured processes. In contrast, there was a large technological gap in the processing of unstructured data. These correspond to data with low-level attributes, mainly images and text, generated directly through human interaction. The relevance of this gap was exacerbated by the IT-driven proliferation of unstructured data. In this context, the great impact of DL has been to fill this gap, triggering a wave of new breakthroughs and research that have defined the direction of progress in AI.

In the visual domain, the revolution has been led by the development of advanced and robust object recognition techniques, which have reached a level of generality and accuracy unthinkable only a few years ago. In this field, open source models such as Yolo and FasterRCNN have facilitated access to these technologies, accelerating their massification and broadening their impact. Moreover, efficient implementations, for execution on graphics cards (GPUs), have enabled real-time operation, opening the door to applications in areas such as robotics. For its part, the detection of human bodies and poses has achieved a remarkable development, for example, models such as DensePose and PifPaf have found a wide range of applications in security, video analytics and medical treatments, among others. Advances in facial recognition have been equally remarkable, leading to the emergence of numerous applications. The problem of visual segmentation has also achieved important advances, highlighting models such as Mask-RCNN and recently SAM. The generation of images through generative techniques with adversarial or diffusion models has also achieved excellent results, revolutionizing fields such as design and video games, among others. In short, the progress in the visual domain has been constant and significant, motivating the most optimistic to indicate that the problem of visual recognition is highly solved.

In the case of text, the main progress has been in the generation of Language Models (LM) capable of being adapted to implement various tasks associated with Natural Language Processing (NLP), such as sentiment analysis, entity recognition, summary generation, response to textual questions, or the implementation of virtual assistants, among others. Initial successes oriented to the creation of semantic spaces for word-level modeling, such as Word2Vec and Elmo, were rapidly evolving towards higher granularity models capable of discovering relations at the level of sentences, such as Skip-Thoughs, or between sentences, such as Bert. In this domain, the recent irruption of large language models (LLMs) with billions of parameters and capable of capturing complex relationships in large texts, have revolutionized not only the NLP area but the entire AI discipline. In particular, LLMs, such as ChatGPT, have demonstrated amazing emerging capabilities that allow them to perform new tasks with minimal supervision, e.g., just a description or explanation of the main aspects of the new task.

The above successes have driven 2 recent trends. On the one hand, there has been an interest in exploring multimodal models that integrate images and text, and even other modalities such as audio and video. On the other hand, there has been a boom in the generation of so-called Foundational Models. These correspond to models of large size (billions of parameters) and generality that can be used or adapted to perform various tasks in the visual, textual, or multimodal domain. Although it is still premature to assess the impact of these new trends, what is indisputable is that they will continue to drive the current AI revolution, in particular, deepening its impact on the visual and textual domains, which will continue to be the protagonists of a revolution in full swing.

Challenges

In terms of limitations and open challenges, criticisms have arisen regarding the robustness of current DL-based AI techniques. Specifically, several studies have shown that many of the current models operate as associative memories triggered by the identification of superficial correlations in the training data. In practice, this implies weak robustness to new situations, e.g., changes in the distribution of input data or attacks by malicious users.

This weakness has generated new research aimed at developing DL variants that allow the identification of causal rules or rules with a higher degree of abstraction than the identification of simple correlations. Another important criticism of DL models is associated with the difficulties in making their internal inference processes transparent. This weakness has generated abundant research in the area known as Explainable AI (XIA), aimed at making transparent the inference process used by an AI model. Topics such as these mark the AI research agenda and exemplify that there are still important challenges to be solved.

Trends to pay attention

In the near future, the main expectation is placed on the emerging capabilities of the Foundational Models. In this regard, it is important to note that the conditions and scope of these emerging properties are still poorly understood by the AI scientific community. Likewise, their limits are also unclear as the size of the models continues to increase in terms of number of parameters and amount of training data. The most optimistic forecasts point to the feasibility of generating AI models of a cognitive level equal or superior to human beings, which has been termed general AI or AGI (Artificial General Intelligence). The most reserved forecasts point to the fact that DL techniques are insufficient to generate reasoning processes with human-like capabilities and new theories are needed to achieve significant advances.

In terms of the impact of these technologies for Latin America. Visual and textual information is highly pervasive in our daily lives. This gives AI the potential to impact our lives in countless ways. Thus, if this potential is harnessed correctly, AI technologies can produce a significant increase in the quality of life of the region's citizens. To this end, the first thing to do is to work energetically on its dissemination in the region and on strengthening the enabling factors that will allow its healthy development. It is also important to make progress on the challenges involved in the implementation of AI, such as the need for appropriate regulations to promote its ethical use, avoid the proliferation of inequalities, protect people's privacy and avoid any negative externalities. In this regard, it is crucial that any legislation be viewed from a local perspective, taking into account the most urgent needs of each country and its priority areas in the social and economic spheres, in order to make AI an effective tool for improving the collective and individual quality of life of the region's citizens.

B. Ethics

State of art and relevance

Because of AI's predictive capacity growth and its potential to address diverse problems, private and public institutions increasingly use AI in systems that impact our daily lives. Beyond controlling the order of our news feeds, search results, and music recommendations, AI predicts recidivism, fraud, and health risks, performs facial and voice recognition, and prioritizes who should get an interview for a job, obtain a loan, or receive child protective services. For many AI systems, evidence alerts us of the harm they can cause, especially to vulnerable populations. When researchers or investigative journalists have been able to systematically interrogate some of these AI applications, they have often uncovered that these systems' outcomes can be biased against women, the elderly, people of color, or individuals who live in poverty, among other marginalized populations.

For example, facial recognition makes significantly more mistakes when recognizing African American women than other demographic groups. When cities use facial recognition for surveillance, these mistakes can lead to severe consequences, such as false criminal accusations. Facial recognition also fails more for visually impaired people, leaving them disadvantaged too. Disproportionate error rates for specific groups of people give shape to an additional form of discrimination at a large scale enabled by AI.

The reasons behind biased results are often associated with the biases embedded in the datasets used to train AI, a phenomenon known as "garbage in, garbage out." This reasoning highlights that the datasets represent our past biased behaviors as part of sexist, racist, classist, and ableist societies. Hence, AI learns these biases from the data and perpetuates discrimination patterns through its outcomes.

Nevertheless, there is also consensus that data is one of many problems. There are intertwined relationships among historical (e.g., gender biases), human (e.g., confirmation and automation bias), and technical biases (e.g., sampling and processing biases) in the AI process that can lead to the AI's problematic results. Multiple biases impact critical decisions at every stage of an AI project, including conceptualizing the organizational problems AI intends to solve, data selection and labeling, AI model processing and evaluation, and how people use and (when possible) contest AI outcomes. Thus, the humans behind AI's development and use and those affected by it take relevance in the discussion about AI's impact on society.

Beyond unfair results, researchers have documented other potential AI harms. They include its extensive use of personal private data, its enormous impact on the environment through energy consumption and mineral extraction, and the potential to replace human labor and dramatically worsen job opportunities for people. There are also concerns about the precarious labor conditions of thousands of workers (mainly in the Global South) who enable AI through key but undervalued tasks, such as data labeling and content moderation. The latter phenomenon is known as the ghost work behind AI. The rise of user-friendly generative AI, such as ChatGPT, has exacerbated further challenges. As AI produces credible synthetic text, videos, and images, we start seeing more pervasive issues with, for example, the AI creation of believable texts with false and misleading information that people use in educational establishments, courts, and other institutions. There is also a proliferation of fake images and videos that enable bullying, sexual harassment (e.g., pornographic deepfakes), and the propagation of fake news. Besides, there is increasing concern about the extensive use of copyrighted data, including paintings and literary works, without proper compensation or recognition for their authors.
Considerations around AI's impacts and potential for harm have prompted numerous studies on ethics and AI. Some research examines whether AI makes morally questionable decisions, a type of machine ethics. Others focus on the moral conduct of the humans involved in developing and using AI and the implications of such behaviors. The latter has recently received substantial attention from disciplines ranging from philosophy and law to sociology, human-computer interaction, and computer science. This work builds upon older disciplines, such as science, technology and society (STS), philosophy of technology, and critical data studies (CDS).

Challenges

Thus, interdisciplinary perspectives have scrutinized several aspects of AI system design and the people responsible for it, focusing mainly on the following:

UNFAIRNESS.

Beyond unveiling biased outcomes in different kinds of AI applications, considerable work in the latest years has focused on providing technical solutions to measure fairness and propose bias mitigation algorithms, tools, and strategies. However, there are multiple ways to define and measure fairness, and it is impossible to generate systems that satisfy all fairness definitions. Thus, the challenges around fairness remain open and current work is leaning towards socio-technical strategies to face them, where AI teams, for example, engage in reflections about which definitions of fairness are appropriate for their context and how the project can articulate strategies to address the challenges of generating fair AI. Other complementary approaches involve regulations and algorithmic audits.

OPACITY.

Another strand of work problematizes the fact that many current applications of AI work as black boxes for users, policymakers, and developers. People often do not understand how AI systems work, making it difficult to question their outcomes and legitimacy as mediators of access to services, information, and opportunities. Besides, people frequently do not know that they are interacting with an AI system or that AI mediates their access to certain services. This fact has led to coin the concept of invisible algorithms, highlighting the difficulty of overseeing AI's impact on our daily lives. Additionally, for deep learning models, although the developers know how the algorithms try to find the patterns to provide precise predictions, they cannot directly know which factors influence a specific prediction. The latter problem has led researchers to work on explainable AI (XAI), discussed in another section of the AI Index. While explainability is likely to address some of the technical challenges of AI opacity, such as methods and tools to increase procedural visibility in models, there is a broader concern for making AI more transparent and understandable to different actors. This aspect involves providing accessible and actionable information to diverse stakeholders, including policymakers, users, and those indirectly affected by AI (without using it). Overall, the expected goal is to design and build AI systems making oversight of their operations possible.

Lack of accountability

Due to current AI issues related to adverse impacts and opacity, there is a broad concern about who is accountable when AI causes harm, even if unintentional. Besides the inherent difficulties in explaining how AI works, many other conscious organizational and individual decisions influence AI outcomes. There is a broad call for creating, adopting, and enforcing mechanisms to document and justify the human decisions behind AI. Research on AI accountability advocates for mechanisms such as data and model documentation, risk assessment and mitigation, internal and external auditing, availability of remedies in case of harm, and regulations that enforce accountability and responsibility assignment. Accountability is also closely related to discussions about responsibility, emphasizing the ethical consideration for morally justified decision-making.

TRENDS TO PAY ATTENTION

While, as a society, we continue to struggle to address these challenges, organizational and public policies have widely embraced one approach: a principled AI. Analogous to bio/medical ethics, they define a set of fundamental principles that should guide AI development and use. The most common AI principles across policies are fairness and non-discrimination, protection of privacy, respect for human rights and promotion of societal well-being, transparency and explainability, accountability and professional responsibility, safety and security, human control of AI, and environmental

sustainability. To a large extent, these principles have yet to be reified in more specific regulations, norms, and organizational and professional practices.
The broad public attention to ethics in AI in the latest years, fueled by the recent calls for AI moratoriums as a response to the hypothetical harms of a general-purpose AI, will hopefully lead to further progress in research, policies, and organizational practices around ethics for both narrow and general AI. Addressing the current tangible harms caused by AI is urgent and essential. Within this area, we anticipate advancement in the following dimensions.

ENVIRONMENTAL SUSTAINABILITY AND AI

Due to the climate change crisis, we expect to see more comprehensive efforts in measuring and controlling the impact of AI on the environment. Upcoming initiatives include improving the visualization and measurement of AI's environmental impact (e.g., more accurate data on carbon footprint). As evidence of AI's extensive energy consumption grows, we foresee trends of moving data centers to use renewable energy (e.g., with sources of hydroelectricity over fossil fuels) and developing more efficient, less resource-intensive, and affordable AI.

SOCIAL JUSTICE AND AI

While concern for fairness will continue, we envision that critical social justice perspectives will have a broader influence on understanding AI impacts and reshaping future AI's goals. We anticipate more research examining the connections between AI and structural social inequalities. While researchers have investigated gender and race inequalities, there is still much to learn about the consequences of AI among people in situations of poverty, individuals with disabilities, and those living in the Global South. Intersectional approaches will illuminate compounded effects of structural inequalities. We also expect to see more work exploring and challenging AI's unequal distribution of benefits and costs. Additionally, growing trends, such as data justice and data feminism, will encourage the development of new imaginaries and socio-technical practices to expand the boundaries of AI's purposes beyond efficiency and surveillance. While this trend might not influence large corporations, we foresee more research and entrepreneurship, especially in the Global South, where practitio

GENDER AND AI

As we move toward social justice, we will continue to observe the realities of gender discrimination in AI and, hopefully, the emergence of more effective ways to eradicate it. AI perpetuates gender discrimination through learning and conveying gender stereotypes in language processing tasks (e.g., translation, search suggestions), computer vision (e.g., misgendering trans people in gender recognition, classifying pictures of women as more sexually suggestive than similar photos of men), and ranking tasks (e.g., downgrading resumes of women who apply for technical jobs). Gender discrimination is foreseeable in specific domains as well. Health research has historically centered on men, accumulating more data about the male body than other bodies; thus, data-driven AI applications for health are likely to perform worse for female bodies. Additionally, generative AI enables new forms of sexual harassment. A 2019 study found that 96% of deepfake videos were pornographic content, all targeting women. Fighting gender discrimination in AI has a long road ahead. We expect to see more gender bias mitigation strategies in place in the following years, more robust efforts to diversify the gender composition of AI teams, and stronger regulations to penalize AI-enabled sexual harassment online and gender discrimination.

REGULATIONS AND THEIR IMPLICATIONS

The European Union is enforcing personal data protection laws and has advanced in proposing one of the first AI regulations globally. Other multilateral institutions, such as Unesco and the UN, provide AI recommendations, which we expect to see translated into public policies in diverse countries. Today, 69 countries, including several Latin American ones, already have an AI policy initiative. Along with policies and regulations, we expect to see developments related to complying with them. Thus, we foresee progress in implementing differential privacy solutions, algorithmic audits, user-centered explainability standards, and transparency requirements.

SOCIO-TECHNICAL APPROACHES FOR PROFESSIONAL RESPONSIBILITY AND TRANSPARENCY

Due to the multiple factors that influence AI's impacts and the opacity of its inner working, interdisciplinary perspectives will become essential to document and justify potentially liable decisions during AI development and use, and the values and intentions behind its design. Moreover, combinations of sociological, ethical, and technical expertise will also help to design better ways to communicate how each AI system works, thus increasing algorithmic literacy and promoting a more comprehensive understanding of AI solutions. They, in turn, can lead to better-calibrated trust in these systems. We foresee more nuanced discussions and interdisciplinary collaborations to delineate AI's impact expectations and limitations better.

FUTURE OF WORK

Due to AI's impressive exponential progress, concerns about its impact on the job markets will become more central in future years. We expect to see more evidence-based AI impact analysis on employment in various public and private sectors, leading to a better understanding of the jobs that might disappear and those that will emerge due to new AI-human work configurations. We also anticipate further research on AI-human collaboration in work settings.

As the concerns around ethics and AI continue to boost research, advocacy, and policymaking, we look forward to witnessing its influence on reshaping how we build, adopt and adapt AI to make our societies more prosperous and just.

C. AI and exact sciences

State of art and relevance

Recent developments like generative AI, computer vision and large language models are enabling technologies and applications that have the power to transform industry, business, social interactions, and our very lives. AI's widespread impact is also revolutionizing the way scientific and technological research is carried out, by redefining the way we approach formulation, design and execution of research activities across disciplines.

Developing a detailed mechanistic understanding of biological processes in living organisms, or of complex physical and engineering systems, requires progressive analyses and integration of new data (e.g., experimental results) in the context of previous data (e.g., published literature). However, this task is becoming increasingly harder for the human mind due to the sheer volume of data and scientific literature. In Biology, for example, the acceleration of data generation due to the advent of omics technologies makes this task virtually impossible to carry out from a holistic perspective. Particularly over the last decade, we have seen a dramatic increase in the number of large, highly complex datasets being generated from biological experiments, quantifying molecular variables such as gene, protein, and metabolite abundance, microbiome composition, and population-wide genetic variation, to name just a few. A similar challenge arises in physics, astronomy and earth sciences due to the deluge of data generated by particle accelerators, and by telescopes and satellite constellations that are continuously observing the Earth and the Universe at multiple spatial and spectral scales. Community efforts across research disciplines are regularly generating petabytes of data.

Since Alan Turing first posed the idea that machines could self-learn and self-instruct from their own experiences in 1950, the field of artificial intelligence (AI) has exploded. Much of the promise of AI in the sciences derives from its ability to discover (or "learn") structure in large datasets and to use this structure to make predictions or perform tasks.
The fields of AI and scientific research are more intertwined than ever, and methods for extracting and applying the information stored in physical systems and living organisms are constantly being refined. As the field of AI matures with more trained algorithms, the potential of its application in many different problems and areas grows. Epidemiology, the study of host–pathogen interactions, drug discovery, customized medicine, gene editing, radiography, image processing and medication management are among many areas where AI is already having an impact.
Recent years have seen impressive advances in AI models (LeCun et al., 2015), showing promising results to uncover complex knowledge and associations based on massive data sources. One outstanding example is AlphaGo (Silver et al., 2016), an AI system able to beat the most proficient Go players in the world. During its match against the Go world champion, AlphaGo produced moves deemed crucial for victory that were completely unforeseen and classified as highly creative insights by experts in the Go game. One of its successors, AlphaFold (Jumper et al., 2021), an AI-based model that predicts the 3D structure of proteins from 1D amino acid sequence, represented a quantum leap from all previous algorithms in protein folding competitions and was selected in 2021 by Science Magazine as the main scientific breakthrough of the year. In the near future, we can envision several ways in which AI will continue to make lasting impacts in scientific discovery:

Trends to pay attention

AI methods for scientific datasets: the capability of AI models to find structure in large datasets and to make accurate predictions for new observations has had a profound impact on scientific discovery and technological transformation across disciplines. In Biology, for example, one of the first applications of AI was the motion tracking software Deeplabcut (Mathis et al., 2018), which analyzes video in order to label the pose of animals, enabling more precise characterization of animal behavior (both of individuals and social groups) during neural recordings or perturbations. Machine learning segmentation and tracking algorithms are also used to reconstruct synaptic connectivity maps from serial electron microscopy data, which has so far resulted in reconstruction of an entire Drosophila brain, the entire mouse retina, and a cubic millimeter of mouse V1 (MI- CrONS Consortium, 2021). Moving to the physical sciences, some outstanding AI results include the prediction cosmological structure formation (He et al. 2019)[20], gravitational wave detection (Huerta et al. 2021)[21], a high-resolution reconstruction of the first black hole image (Medeiros et al. 2023)[22], the discovery of new materials (Pyzer-Knap et al. 2022)[23], and the autonomous control of plasma in hydrogen fusion reactors (Degrave et al. 2022)[24], which brings clean nuclear energy one step closer. Overall, AI-driven frameworks for processing of scientific data are accelerating critical results in practically all research areas, and more such breakthroughs are sure to come in the coming years, in a wide range of domains.

AI-assisted computational simulations: state-of-the-art numerical simulations used to validate theory against large-scale datasets in fields like climate science, cosmology, particle physics and fusion energy have reached computational costs that are prohibitive for most. Therefore, it becomes unfeasible to run massive experiments required to understand and test the behavior of mechanistic models for the full range of possible physical conditions, or over extended timescales. As a research direction, a variety of AI methods can be used to train surrogate models that provide a simple yet faithful representation of the full system, and in turn, these surrogate models can be used to generate massive ensembles of simulations at a reasonable computational cost. Moreover, AI algorithms can be used to increase the resolution, size, timescale and number of interactions that can be modeled for a given system (Kasim et al. 2022, US DOE 2023)[25]. These AI-assisted computational approaches will be key to enhance our ability to study complex dynamic processes like climate evolution, formation of universe large-scale structures, and multi-physics earth processes such as tsunami and earthquake propagation.

Physics-constrained AI: extensive data availability in some fields have lead to the development of purely data-driven approximations for various physical, chemical or biological systems. However, this approach is hindered in several scientific applications where training data is still scarce due to experimental cost and technical limitations, and does not guarantee compliance with established physical first principles and domain expertise. Moreover, while AI succeeds in generating accurate predictions for physical and biological systems, the ultimate goal of scientific research is to obtain a robust understanding of the underlying processes, and to grasp the laws and causal relations that govern them (Krenn et al. 2022)[26]. A possible

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solution is to feed AI algorithms with our previous knowledge on the laws, mathematical models, and constraints that apply to a given physical system. This can be done, for example, by embedding underlying differential equations or domain-specific restrictions within the AI architecture and training process, or by pre-trainning the model with data simulated with mechanistic models. Such physics-based algorithms can perform and generalize better in small and noisy data regimes, they can be used to learn model parameters or equations that describe high-dimensional physical phenomena, and the use of physical principles may even help interpret and test the inner workings of deep learning models (Karnadiakis et al. 2021)[27].

AI-assisted scientific exploration: Self-supervised learning, where an AI model is trained using self-generated labeled data, is at the core of the success of AI models such as AlphaGo and AlphaFold. In effect, by creating its own prediction challenges, an AI model is able to extract useful knowledge from an almost unlimited amount of data. As an example, in the context of Natural Language Processing or NLP, self-supervised large language models, such as GPT-3 (Brown et al., 2020) or PaLM (Chowdhery et al., 2022), have demonstrated impressive abilities to extract meaningful pieces of world knowledge from being exposed to an extremely large quantity of text (billions of words). A relevant challenge is related to how to access the knowledge encoded by the internal representation of a large AI model. As a surprising finding, recent research (Gao et al., 2021; Zhong et al., 2021) have found that it is possible to steer these large models to output relevant knowledge from a novel target task using just a prompt. Specifically, by using a prompt to provide to the model a human language description or several examples of what one wants them to do, the model can output meaningful knowledge related to a target task. This learning strategy, referred to as contextual prompting, offers a new degree of control to selectively access the knowledge encoded in the internal representations of a large language model. In turn, this opens a new disruptive way to conduct AI-assisted scientific exploration and discovery. We posit that such AI models trained on the existing scientific literature or data, can induce new ideas or synthesize knowledge in ways that cannot be done today by individuals or groups of scientists. Furthermore, by providing suitable prompting and in-context learning schemes to query a model, these models can provide scientists with a highly powerful tool to explore the knowledge encoded by the model, retrieving novel connections between existing information that were not appreciated before or hypotheses that ultimately should lead to new discoveries. Large graph-based neural approaches can also be leveraged to build semantic knowledge networks from large bodies of scientific literature, from which conceptual relations and unexplored research lines may be identified (Krenn et al. 2022). We believe these advances represent a tipping point in the way scientific research is carried out, reconceptualizing science as an optimizable feedback loop between AI and scientists.

Challenges for AI and Scientific Discovery in Latin America.
As described in the previous sections, it is now clear AI will pervade and nurture all branches of science. There are many fields where Latin American countries can leverage the power of AI technologies both from a general perspective as well as driven by and directed toward local needs. We have unique and extreme natural laboratory conditions in places such as the Amazon, Atacama Desert, Andes Mountains, Pacific and Atlantic oceans, to name just a few. These natural laboratories harbor a unique genetic biodiversity in macro as well as microorganisms waiting to be discovered. New research efforts are needed to understand this extraordinary biology and Latam should play a major role. Understanding biology is the first step to develop new biotechnologies with applied purposes that can serve local as well as worldwide needs.

Latam should also lead the development and deployment of new more efficient technologies for agriculture that allow for sustainable and resilient food production in the face of climate change. Latin America and the Caribbean region plays a vital role in producing food and ecosystem services that benefit not only the region itself, but the entire planet. New strategies will be also required to mitigate the ecological impact of natural resources exploitation (e.g. mining, forestry) as well as to reduce pollution of our cities. Moreover, there are unique local challenges that will need to be addressed locally. Health issues that are prominent in Latam due to particular pathogens, unique genetic composition as well as lifestyle choices will need to be addressed locally. Finally, due to its geotectonic setting and long-term effects of global warming and sea level rise trends, Latin America is particularly prone to geological (earthquakes, volcanoes) and hydrometeorological hazards (cyclones, floods, drought, cold/heat waves) that are becoming more frequent and extreme. The region is in an exceptional position to tackle the physical processes behind these phenomena, their potential impacts and possible mitigation and adaptation strategies. A combination of global remote sensing datasets, unique regional sensor networks, and AI methods tailored to integrate these diverse data sources with complete or partial mechanistic models and forefront computational simulations are needed to anticipate disasters.

In other scientific areas Latam already plays a leading role. For example, Chile already concentrates more than half of the world's astronomical capacity, and is currently the construction site of future giant visible-infrared observatories like the Extremely Large Telescope (ELT), the Vera Rubin Observatory, and the Giant Magellan. Other ongoing projects like the Tokyo Atacama Observatory (TAO), the Simons Observatory and the Cherenkov Telescope Array will also map the universe at very low and high energies, from microwave frequencies to gamma rays. In combination, these observatories will provide a multi-scale, multi-wavelength and temporally-continuous view of the full sky. The massiveness and complexity of such data exceeds the processing and analysis capabilities of traditional computational methods, and AI will become a key tool to extract, model and understand signals from exoplanets to the cosmic background and large scale structure of the universe, and to reveal the new physics that may be hiding in them.

Latam universities, research institutes and government research units must embrace the new wave of AI and use the power of this new technology to play a leading and vital role to address these problems and develop new solutions for Latam and the world.

27. https://doi.org/10.1038/ s42254-021-00314-5

D. Explainable AI (XAI)

State of art and relevance

Current models of artificial intelligence, such as deep convolutional networks and attention-based architectures like Transformers, have achieved impressive results in predictive tasks related to multiple domains. Their success lies primarily in their ability to achieve very high accuracy rates in classifying examples over large datasets. To achieve this accuracy, these architectures adjust up to hundreds of billions of parameters, allowing them to detect highly complex patterns in the data that are invisible to simpler models with fewer parameters.

However, there is an important tradeoff that we must consider with these architectures: as we increase the number of parameters they use and therefore their accuracy, we decrease our ability to understand which factors are most influencing the resulting prediction. This is a significant issue because the only way we can have an operational and deployable AI that serves people is through the development of methods whose actions can be understood and evaluated by humans. There are multiple reasons justifying this need, including the increasing use of AI in critical applications (defense, healthcare, self-driving vehicles, etc.), the ethical obligation to understand and eliminate biases in the data used to train our AI models, the growing demand for regulation of the algorithms used in the field today, and The need to provide mechanisms that allow humans to interact with AI algorithms.

In recent years, there has been notable progress in the development of Explainable AI (XAI) to address the demand for reliable interpretation methods for AI models. This progress has resulted in significant applications of XAI in various fields. For instance, in the realm of radiology, where deep learning is increasingly used to classify medical images for different conditions, techniques like saliency maps and attention mechanisms are employed to explain to radiologists which parts of the image influenced the AI system's decision. This allows radiologists to validate and refine the recommendations made by the AI system. Additionally, XAI is being utilized in the analysis of satellite imagery and sensor data to monitor and provide explanations for environmental changes such as deforestation, pollution levels, and climate patterns. The insights derived from XAI in these areas can inform policymakers and citizens, enabling them to make well-informed decisions regarding conservation efforts and sustainable practices.

Challenges

Despite the rapid progress in the field of XAI, there are several important challenges that have yet to be solved. Below, we mention some of these, which are likely to be the subject of much research in the coming years:

EXPLANATIONS FOR COMPLEX MODELS:
A common way of providing explanations to AI models, particularly to answer the question of why the model gave this result for this particular input, is through analyzing the contribution of each feature in that input to the output of the problem. These methods are typically model-agnostic, meaning they do not depend on the internal characteristics of the models being analyzed. In spite of this, they cannot be used for complex models based on neural networks as their implementation becomes computationally expensive. Although several methods have been proposed to alleviate this problem, including compiling complex models into simpler ones for which explanations are easy to compute, we still lack a complete understanding of when these methods can be applied and whether better methods can be used in certain situations.

USER-FRIENDLY LANGUAGES FOR COMPUTING EXPLANATIONS:
In most situations, providing an explanation for the output produced by a model requires a combination of different methods and metrics that have been proposed to quantify the contribution of different features. This implies that only expert users can construct such explanations, as this process involves an elaborate interaction with the model and a sophisticated understanding of its internal characteristics and the application domain in which it is being used. The lack of availability of XAI experts is an increasingly common problem, especially in environments where AI algorithms are implemented. It is unrealistic to expect that there will always be an XAI expert available to interact with the model and provide explanations. As a result, solutions have been proposed to address this problem, and one of the solutions is the development of declarative languages for computing explanations about AI models. These languages allow users to declare what they want to understand from the model and enable an automatic system to generate explanations instead of constantly having to program them. This solution can allow non-expert users to better understand AI models and the decisions they make. However, further research is still needed in this area to ensure the effectiveness and accuracy of these declarative languages.

CAUSALITY:
One of the main challenges for XAI in terms of causality is the difficulty in identifying and separating causal relationships from correlations in complex models. Correlation does not imply causation, and therefore, identifying the causal relationships that lead to a particular prediction is crucial for providing meaningful explanations. However, it can be challenging to distinguish between the causal relationships and spurious correlations that may arise from complex models.

Trends to pay attention

We foresee the application of XAI techniques in many contexts in the near future, including several contexts that can be of particular relevance for Latin America. We provide some examples below:

POLICY DECISION-MAKING AND GOVERNANCE:
In our view, a significant area where XAI techniques can be applied in Latin America is to enhance the citizen-state relationship, with the goal of improving transparency and fostering trust in institutions. As the use of data-driven techniques and algorithms to analyze complex situations by governments continues to increase, it will become increasingly important to provide satisfactory explanations to citizens regarding the outcomes of these processes. In particular, guarantees must be provided that these results are free from biases and manipulation. This is of special importance in Latin America, as the region has a long history of political instability that has eroded citizens' trust in their institutions.

SMART CITY PLANNING:
XAI will be used in various ways to assist in the process of city planning in the future. For example, we can mention the use of XAI techniques to support the optimization of resource allocation in different areas of the city. By providing explanations for the decisions made by AI algorithms in this context, such as determining optimal routes for public transportation or deciding where to build a hospital, planners will be able to better understand both the algorithm and the city itself. This knowledge will enable fine-tuning and adjusting resource allocation strategies to better align with specific urban needs and priorities. Once again, this holds significant importance for Latin America, as the efficiency of resource allocation directly tackles specific structural conditions in the region pertaining to poverty and inequality.

NATURAL DISASTER MANAGEMENT:
Latin America is prone to various natural disasters, including earthquakes, hurricanes, floods, and wildfires. By employing XAI techniques, disaster management agencies will be able to provide transparent explanations for patterns and trends, enabling decision-makers to gain insights into the potential impact and trajectory of a disaster. In addition, XAI can also contribute to the development of early warning systems by being capable of identifying early indicators of potential disasters.

E. AI and Arts

State of art and relevance

This section, which is not intended to be exhaustive, delves into the current landscape of AI integration with several art forms across Latin America. Similar to other regions, over the last decade, Latin America has experienced a rapid increase in the use of AI technologies in the arts. The use of these technologies, however, is not homogeneous throughout the region. Access to these technologies varies not only from country to country. Great discrepancies also exist in the use of AI within countries. Access to AI tools depends on many factors, such as infrastructure, connectivity levels, access to technology, and other socioeconomic variables in the region. Nevertheless, this has not hindered the ever increasing use of AI and its impact on various artistic expressions.

Latin American countries display a very heterogeneous spectrum of technological development, which directly affects the extent of AI integration in various art forms. Nations like Uruguay, and Chile, for example, possess robust digital infrastructures, high internet penetration rates, and widespread access to cutting-edge devices. This technological prowess enables artists in these countries to embrace sophisticated AI tools and delve into complex AI algorithms and machine learning models for their artistic expression. On the other hand, in countries with more limited resources and technological advancement, such as Bolivia, Paraguay, and some rural regions in countries with more robust digital infrastructure, artists face more challenges to fully embracing AI in their works. Internet connectivity and access to advanced devices might be limited, impacting the scope and depth of AI applications. In spite of these constraints, these countries often foster unique collaborations (such is the case of Cuba) with international organizations and artists, leading to creative AI initiatives.

AI has had one of the most “visible” impacts on the visual arts in Latin America. The use of AI-generated visual art is flourishing across Latin America. Ranging from wide spread use in photography, presentation design, and website creation by the general public, to more sophisticated uses by professional artists and institutions. A quick look at the internet allows us to see a number of websites and web pages generated in Latin America that incorporate AI technologies into their rich designs. Institutions are integrating AI techniques into their creation processes, curation of installations, designs, and data analysis. A concrete example of this application is the use of AI in some museums, where AI has been used to generate exhibitions that include the use of facial recognition algorithms to provide a more individualized experience for the attending audience.

Visual artists are increasingly using AI algorithms to aid in the production and processing of photography, digital paintings, sculptures, and interactive installations. Several artists are incorporating AI-generated poetry and responsive installations, where audience participation shapes the evolving artwork. Other artists are experimenting with AI-driven installations that respond to real-time data, producing immersive and ever-changing art experiences. These are just a few examples of applied AI in the visual arts.

In the realm of music, AI is being used across various media and by different actors, leading to significant innovations. The fusion of AI and music has led to groundbreaking innovations in Latin America. Musicians and composers are using AI algorithms to assist in composition, generate new sounds, and enhance live performances. Companies are leveraging AI to provide personalized music education platforms that adapt to individual learning styles.

The impact of AI in the music industry can be seen in the way music is being composed, performed, commercialized, and consumed. At a consumer level, music apps and websites utilizing AI are revolutionizing the way music is distributed, purchased, and shared. Services like Spotify, Deezer, Amazon Music, Apple Music, present in Latin America, rely more and more on AI algorithms and shape the way music is consumed in the region. These AI-powered music recommendation systems are helping audiences discover new music and diversify their listening experiences.

At the production level, advances in AI in the form of apps, plugins, and dedicated websites allow individuals without previous musical training to create music in diverse styles (hip-hop, jazz, etc.) and with different levels of sophistication. Some of the most used sites for AI-generated music include Aiva, Amper Music, Muber, Infinite Music, Jukebox by ChatGPT, and many more. At a professional level, more and more musicians, composers, and producers are using music notation programs (Sibelius, Finale, etc.) and DAW (Digital Audio Workstations) such as Logic Pro, Ableton, etc., as opposed to traditional ways of composing using pen and paper.

These and many other programs and apps are increasingly integrating AI capabilities in the form of plugins and modules added to music production softwares. Some of these tools facilitate or automatize the completion of simple mechanical tasks. While others, offer more sophisticated capabilities that increase production and facilitate the exploration of new musical ideas generated by AI algorithms. Although still a minority, many musicians are collaborating with AI algorithms to generate melodies, harmonies, and rhythms.

AI is making its mark in the realm of literature and creative writing in Latin America. NLP algorithms are being used to analyze literary works from different regions in the world, empowering authors to explore innovative narrative styles and themes. AI offers professional and non-professional writers the possibility of researching topics, creating outlines, employing AI-generated plots and characters, and many other resources that help expedite and enhance their creative process. AI is being used by students of all levels (AI can suggest improvements, correct grammar, offer stylistic suggestions, etc.) and there are an increasing number of initiatives to include pedagogical use of AI as a learning tool inside and outside the classroom.

At a professional level, in countries such as Colombia, Mexico, and Argentina, to name just a few, there are several examples or “collaborations” in which, in partnership with an AI language model, authors have experimented co-writing scripts, short stories, and novels, taking advantage of the potential of collaborations between human and AI creativity. These experiences, however, are not free of controversy. Many issues of authorship, copyright, and compensation to the rightful authors still exist (something we’ll discuss later in this article).

AI can also aid in promoting cultural diversity and representation in Latin American literature. By analyzing diverse literary works from the region, AI algorithms can help identify patterns, themes, and commonalities that highlight the unique voices and experiences of Latin American authors. Finally, AI is also being used to enhance translation and language learning tools, facilitating the exchange of literary works across different cultures and languages.

While AI-generated content can be impressive, some argue that it lacks the depth of human emotions and experiences that make traditional literature compelling.

AI is also changing the performing arts scene in Latin America, fostering interdisciplinary collaborations and expanding creative boundaries. Dance companies are incorporating AI technologies to create immersive performances, blending movement with interactive visuals. In theater, AI-driven chatbots have been used to engage audiences and facilitate interactive storytelling experiences. Additionally, AI-powered virtual reality (VR) and augmented reality (AR) technologies are being employed to create interactive and immersive exhibitions that redefine audience engagement. Although potentially a great tool, issues of access and high costs have limited the use of these latter new technologies to a very few experiences in Latin America.

Challenges

There are many challenges and ethical considerations that must be addressed before all the potential benefits of AI can be fully realized. Some of the most important challenges have to do with ethical concerns, bias in AI algorithms, intellectual property, dependency in external support, laws and regulations, and the potential loss of human touch and intuition.

AI algorithms can inadvertently perpetuate cultural biases present in their training data, leading to AI-generated art that may lack sensitivity to diverse cultural norms. AI algorithms may promote popular global trends in art, leading to the loss of unique cultural expressions and traditions in Latin America. For example, if AI-generated music is primarily based on mainstream Western genres, it might overshadow traditional Latin American musical styles and instruments, reducing cultural diversity. Addressing and rectifying these biases is crucial to ensure AI-generated art respects and represents the rich cultural diversity of Latin America.

Just as AI tools could help "democratize" the way art is produced and consumed, as AI-driven art gains prominence, traditional artists in Latin America might struggle to compete with automated and mass-produced works. For instance, AI-generated paintings might flood the market, making it challenging for local artists to earn a living from their handcrafted pieces, leading to economic inequalities in the art industry.

Additionally, there is the concern of potential job losses. There is an abundance of evidence from animation, advertising, and video game studies showing that they are laying off members of their creative teams in order to reduce production costs by using AI. Avoiding job losses due to AI requires a proactive and strategic approach from individuals, businesses, and governments, fostering a collaborative environment between humans and AI, and focusing on human-centric roles that leverage emotional intelligence and creativity.

Defining ownership and copyright of AI-generated artworks poses complex legal challenges. Determining the rightful claimants, which could include the AI system's creator, the artist, and the platform or dataset provider, requires careful consideration and clear legal frameworks. According to the Manifiesto by Colectivo Arte es Ética, one of the "negative aspects common to almost all AI models in the market, is that they dilute the authorship of the sources from which they derive their capabilities through deep learning." The process of training these generative AI models involves using vast datasets of human-generated content, raising questions about compensation and ownership of such AI-generated works.

Artists in countries or regions with limited technological infrastructure may face challenges in accessing and effectively utilizing AI tools. Latin American governments and organizations need to foster localized AI development and educational initiatives to reduce dependence on external support and foster sustainable artistic growth.

An overreliance on AI-generated art could diminish the value of human creativity and the emotional depth conveyed through traditional art forms. For example, an AI-generated poem might technically follow all the rules of poetry but lack the genuine emotions and experiences that a human poet could infuse into their work.

Other ethical considerations have to do with content. For instance, if an AI creates visual art that includes offensive or inappropriate content, it could lead to controversies and debates about the responsible use of AI in artistic expression. Addressing these dangers requires a comprehensive approach involving artists, developers, policymakers, and society. It involves developing AI algorithms that are sensitive to cultural nuances, promoting diverse and inclusive AI datasets, establishing clear guidelines for copyright and ownership of AI-generated art, and encouraging a balanced approach that respects both AI-driven creativity and traditional human expression.

Trends to pay attention

A responsible and ethical use of AI technologies could offer many benefits to the arts in the region. But it is becoming imperative that regulations and ways to implement them be put into place. AI enables artists to explore new creative possibilities, engage with audiences in innovative ways, and foster cross-disciplinary collaborations. AI could potentially play a vital role in preserving Latin American cultural heritage by facilitating the process of digitization and restoration of invaluable artworks, oral traditions, ancient artifacts, manuscripts, etc. By conserving and digitizing these works, the use of AI ensures their accessibility to future generations while safeguarding them from deterioration and loss.

AI tools can also aid artists in the execution of mechanical tasks, freeing artists to dedicate more time to their creative process. Additionally, AI can serve as catalysts for artists, augmenting their creative boundaries and offering fresh perspectives. This amplification of creativity encourages Latin American artists to explore novel artistic concepts and experiment with unconventional ideas, fostering a new wave of innovative and thought-provoking art.

The integration of AI in art creation, if done properly, could also help democratize the artistic landscape in Latin America. AI-driven tools and platforms could potentially become more accessible and affordable than traditional art tools, enabling a broader range of artists, especially those with limited resources, to participate in the art scene and share their creations with a global audience.

The integration of AI in the arts in Latin America showcases a dynamic interplay between tradition and innovation. The current AI applications in visual arts, music, literature and other art forms could help emphasize the region's creative potential, amplified by technological advancements. While AI offers numerous benefits in preserving cultural heritage, enhancing creativity, and democratizing art, addressing ethical considerations, biases, intellectual property concerns, and dependency on external support remains imperative for fostering a more responsible and inclusive AI integration in the arts. By embracing AI with ethical awareness, Latin America can foster a more vibrant and culturally resonant art scene that bridges the past and the future.