

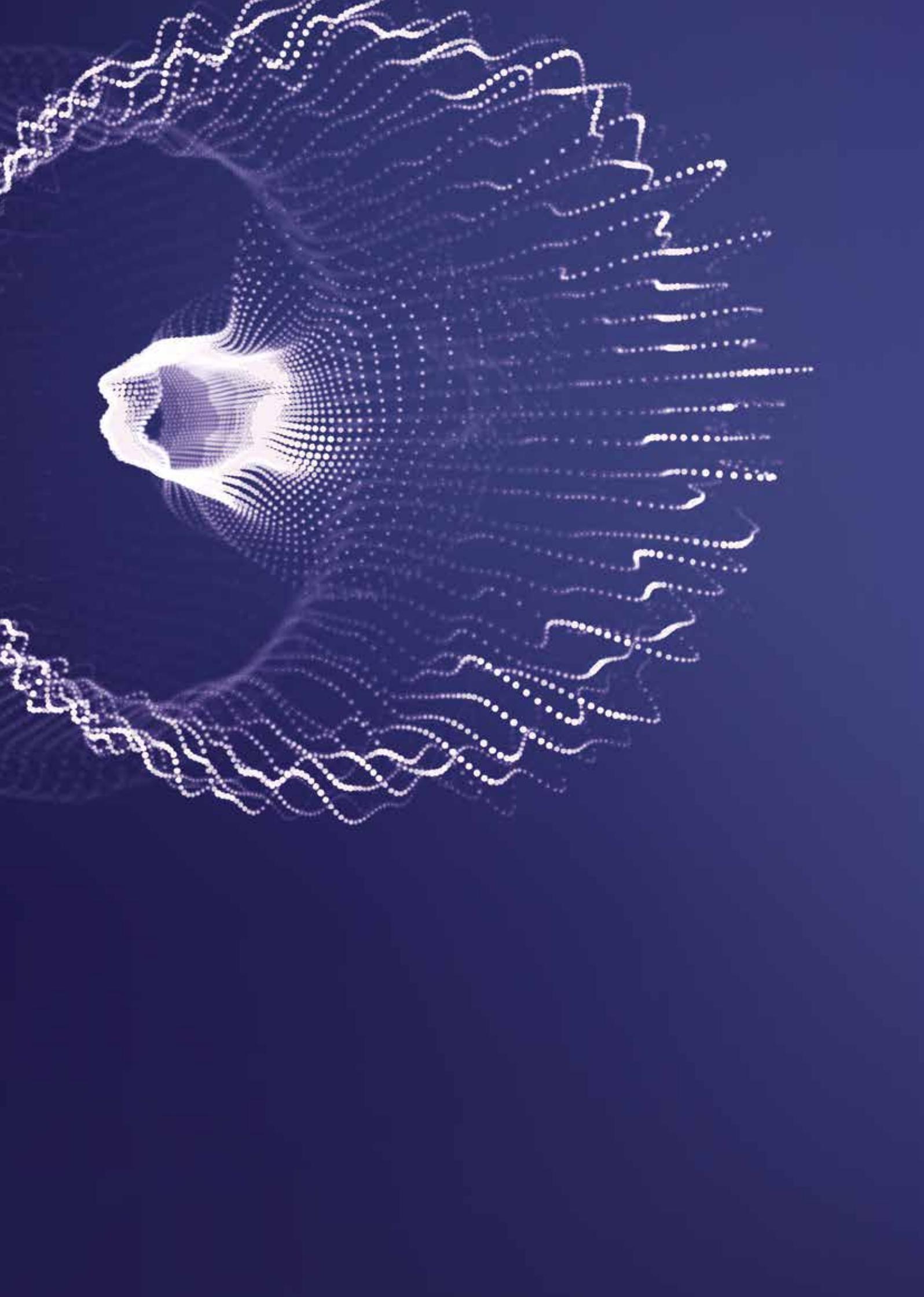
PORTUGAL
INCoDe. 

AI PORTUGAL 2030

**PORTUGUESE NATIONAL
INITIATIVE ON DIGITAL SKILLS**

An innovation and growth strategy
to foster Artificial Intelligence in
Portugal in the European context





Promoted through the Coordination Office of INCoDe.2030 Initiative in close cooperation with the Portuguese Science and Technology Foundation (FCT), The Portuguese Innovation Agency (ANI), Ciência Viva and the Portuguese Agency for Administrative Modernisation (AMA).

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PORTUGUESE NATIONAL
INITIATIVE ON DIGITAL SKILLS

An innovation and growth strategy to foster Artificial
Intelligence in Portugal in the European context

AI PORTUGAL 2030

a dynamic and evolutive process

SEPTEMBER 2016
initial preparation of INCoDe.2030, a national initiative to foster digital skills

7 DECEMBER 2017
First National Forum on Digital Skills - INCoDe.2030, including specific sessions on AI

JANUARY 2018
preparatory meetings and consultations for developing new research activities and further developing competences in AI within Public Administration in Portugal

MARCH 2018
launching of "FCT's Mobilising programme to foster AI in the public administration", through a competitive call for R&D projects promoted by FCT

OCTOBER 2018
presentation of 19 R&D projects funded by FCT, under the "FCT's Mobilising programme to foster AI in public administration"

APRIL 2017
formal launching of INCoDe.2030, with five lines of action: inclusion, education, qualification for employment, specialisation and research

JANUARY 2018
Portugal participates actively in the preparation of the "European AI declaration" with the EC's DG Connect

FEBRUARY 2018
Identification and launching of four pilot R&D projects to foster AI within Public Administration, in close interaction between FCT and AMA

APRIL 2018
Portugal signs the "European AI declaration", during the second EU digital Day, Brussels

OCTOBER 2018
kick-off for a specialised team to prepare an **AI Portugal 2030 strategy** within the scope of INCoDe.2030

●
NOVEMBER 2018
preparatory meetings
and consultations
for **AI Portugal 2030**
strategy

●
JANUARY - FEBRUARY 2019
consultations with different
entities and business
enterprises

●
FEBRUARY 1ST, 2019
presentation and expert
discussion of the **AI Portugal**
2030 strategy at Carnegie
Mellon University, Pittsburg, in
the context of the Carnegie
Mellon-Portugal Programme

●
FEBRUARY 15TH, 2019
presentation and public
discussion of the **AI Portugal**
2030 strategy at FCUP,
Porto, with representatives
of research centres working
on AI

●
MARCH 1ST, 2019
"FCT´s Mobilizing
programme to
foster AI in public
administration",
through a
competitive call
for R&D projects
promoted by FCT
- second edition

●
DECEMBER 12TH, 2018
presentation and
public discussion
of a draft version
of **AI Portugal 2030**
strategy in the second
National Forum on
Digital Skills
- INCoDe.2030

●
JANUARY 14TH, 2019
launch of a call within the System
to Support the Modernisation
and Capacitation of Public
Administration (SAMA2020)
to finance Data Science and
Artificial Intelligence projects
within Public Administration

●
FEBRUARY 12TH, 2019
presentation and
public discussion of
the **AI Portugal 2030**
strategy at INL, Braga,
with EC´s Deputy DG
Connect

●
FEBRUARY 25TH, 2019
presentation and
public discussion of
the **AI Portugal 2030**
strategy in Porto,
together with the
presentation of OECD
2018 S&T Outlook

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01

FOREWORD



**Manuel
Heitor**

**Minister
of Science,
Technology
and Higher
Education**

The goal of our "AI Portugal 2030" strategy is to foster a collective process mobilising citizens at large and key stake holders in particular, towards building-up a knowledge intensive labour-market with a strong community of forefront companies producing and exporting AI technologies supported by research and innovation communities involved in excellent high level research.

In the coming decade, AI technologies should be easily available to promote the efficiency and quality of all activities, including SMEs, public services, and every citizen. This requires qualifying the labour force and a guarantee that Portugal will be at the forefront of AI Education for all. AI will improve the quality of services and the efficiency of processes while guarantying fairness, wellbeing, and quality of life.

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This strategy is fully aligned with the Coordinated Action plan of the EU and their Member States and is included in INCoDe.2030, the Portuguese initiative to foster digital skills. It considers and promotes a coordinated approach at a European level encouraging the use of this powerful technology to help solve the world's biggest challenges, from health to climate, from transport to agriculture, and from cybersecurity to industry in general.

The current text is the result of a long dialogue over the last two years and should continuously evolve

as a dynamic and collective effort with annual reviews and a systematic process of mobilising citizens at large, and key stake holders in particular. The main general objectives include **added economic growth, scientific excellence, and human development** increasing dramatically the qualifications of the labour force, particularly its technological qualifications, while promoting inclusion and awareness at all levels of education.

But it should be clear that the growing usage of AI must also strengthen **societal robustness** by building a

ADDED ECONOMIC GROWTH, SCIENTIFIC EXCELLENCE AND HUMAN DEVELOPMENT

clear vision of the impacts of AI in democracy, privacy, security, fairness, the labour market, governmental and commercial transparency, and equity. Although AI is highly disruptive in all these dimensions, it also provides, when it is made **ethical-by-design**, a set of powerful tools to actually improve society and democracy.



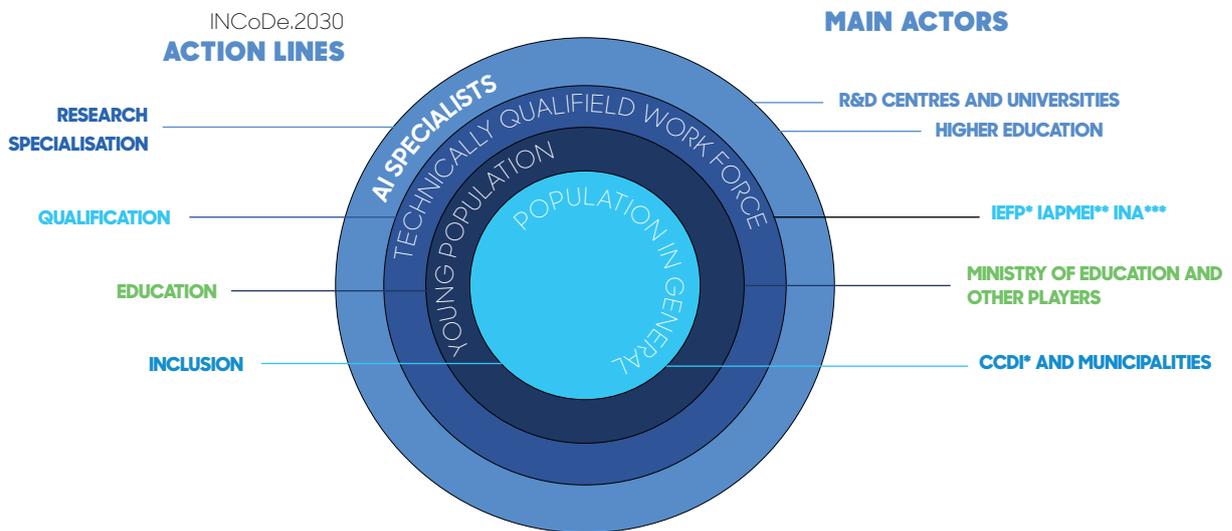
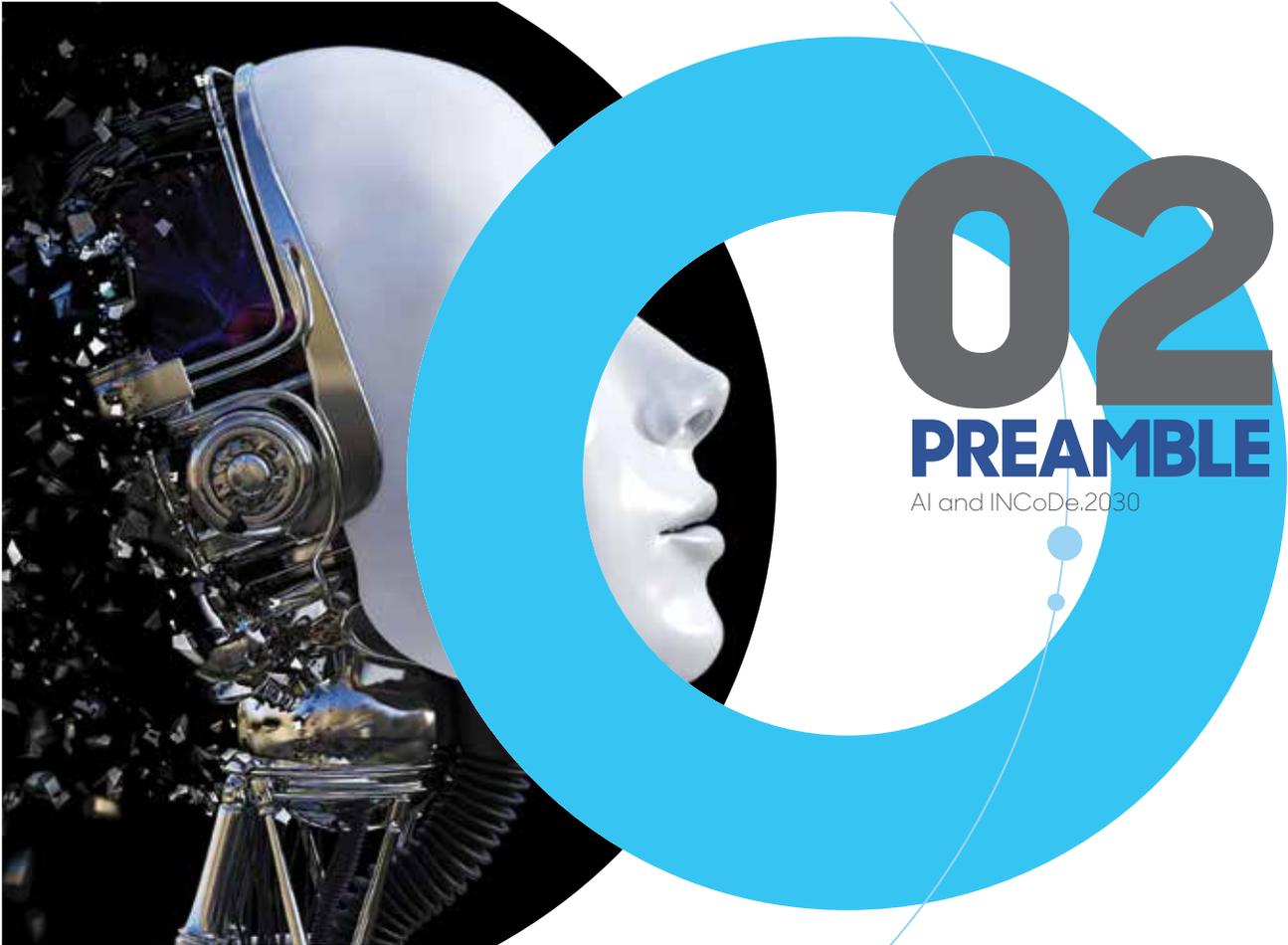
**Alípio
Jorge**
Coordinator
of the "AI
Portugal
2030" National
Strategy

More than two thirds of a century ago, Alan Turing, a European, published an article with the question "Can Machines Think?" where he proposed the "Imitation Game", a test that intended to determine whether or not an artificial agent could be considered intelligent. The exact term Artificial Intelligence (AI) would appear in 1955 branded by McCarthy, Minsky, Rochester and Shannon, four American pioneers in AI and Computer Science. After that, the area has developed worldwide to a mature scientific field with important applications in Robotics, Planning, Expert Systems, Natural Language and Game Playing. In Portugal, the field started to grow in the 80s with a few pioneers working in areas such as Knowledge Representation, Logic Programming, Machine Learning, Natural Language Processing and Multi Agent Systems. By that time, we had the first Portuguese Conference on AI and the launching of the Portuguese AI Association. But until recently, the society and the media saw AI mainly as a science fiction must. Through the 90s, however, the scenario started to change rapidly due

to the growing flood of data coming from Enterprise Information Systems, the World Wide Web and the enormous spread of sensors in our cars, our phones, our gadgets, our environments, and our homes. This abundance of data combined with the ever-growing computational power and a strong business innovation landscape gave rise to new machine learning models, which during this decade boosted the whole of AI to a golden era. Other developments and achievements in autonomous vehicles, robotics, game playing and natural language understanding made the field emerge to a broad public recognition. Artificial Intelligence has now reached the economy in the developed world and beyond and is a main asset of big and small technological companies. It is predicted that AI technologies will have a significant impact in the economic growth of the developed countries and of the world as a whole over the next decade. Europe has pioneered and excelled in AI and technological research, it has strong worldwide players and it is definitely well positioned to develop and adopt AI. However, Europe also faces the threat of increasingly depending on technology that is not made here. The US is leading in many AI domains; China dominates the microchip industry and is investing heavily to become the AI world leader by 2030. Most importantly, the convenience of the widespread adoption of AI cannot hinder the human-centred European values. Privacy protection, safety, transparency, fairness and inclusion must be ensured in the European space. In 2018, the Member States of the European Union agreed on defining a Coordinated Action Plan, which would help shape and articulate the national strategies of each country, promoting strong AI research and innovation and incor-

porating ethical principles by design. Portugal, mainly through the Ministry of Science, Technology, and Higher Education led by Manuel Heitor, and the Ministry of Economy led by Pedro Siza Vieira, is actively involved in this effort. It also naturally articulates with the national programme for digital skills, INCoDe.2030 coordinated by Pedro Guedes de Oliveira. This document for the Portuguese AI strategy is the result of the first round of discussions made by many representatives from Research, Academia, Companies, and Public Administration. Just as the new AI revolution is only beginning, this document is the starting point of a strategy that aims to bring together AI producers, researchers, up-takers, consumers, policy makers and the society as a whole in order to push Europe and Portugal to a bright future. I was the main editor and this would not have been possible without the contributions of many who suggested, rewrote, reviewed, inserted, underlined and criticised parts of it. To all these contributors my personal acknowledgement.

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Following in the footsteps of mass digitisation, which has already been changing world economy and societal fabric, AI will accelerate and amplify the process. To think ahead and prepare action plans in digital matters is important not only to properly handle the pitfalls but also to take advantage of the emerging

opportunities. The impact on people's life and the challenging pace of change of technology enhance the importance of an AI National Strategy that builds on the analysis of its developments and applications to focus on domain specific questions such as the AI preparedness of Portuguese economic, social,

and cultural landscape, the role of government, and how to involve the research community in the entire process. However, the setting upon which the so-called AI revolution will unravel is far larger than an AI Strategy can handle, so INCoDe.2030, in all its five action lines, has to prepare the ground for its sound implementation.

Inclusion

Digital inclusion aims at providing the vast majority of Portuguese population with minimum knowledge and skills that will allow for them to use the tools available in their current life to understand the potential benefits that new digital and frequently AI based solutions can bring to their lives, but also to understand the risks and threats they have to face, from being screened and targeted with false information to being driven to options that are not necessarily in their benefit. Moreover, safety and privacy are critical issues where an acute sense of risk and responsibility should be achieved.

"Creative Communities for Digital Inclusion" (CCDIs) that, under IN-CoDe.2030, are being developed around the country and in close cooperation with municipalities and other local organisations to help vulnerable and digital excluded communities develop the necessary competences and understand the living context induced by the Digital Transformation and particularly AI. For some communities, due to deeper factors of exclusion ranging from age and lack of qualifications to ethnical or other issues, digital autonomy is hard to achieve and can only be reached by tailored and networked solutions attaining at each cultural environment counting on mentors and assistants who have to be trained to help and assist on a daily basis.

Education

It is very important to contemplate an education strategy with an early introduction of the fundamental concepts of Computer Science complemented by Information and Communication Technology (ICT)

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learning through its integration in the curriculum of other disciplines. Moreover, given its importance, concepts of AI should also be considered at an early stage of schooling. This could be done through examples like

- i) teaching young students the fundamentals of machine learning using *Ciência Viva Clubs* located in schools and Science Clubs – already present in many places –, taking as examples of challenges current global problems from biodiversity or pollution studies;
- ii) developing creative / collaborative multimedia contents in science, be it on key Science, Technology, Engineering, Mathematics (STEM) subjects like human biology and the energy ecosystem, or on Portuguese regions, geography, and history, and many other subjects.
- iii) developing programming capabilities and leveraging on the high expressiveness of programming languages and platforms to create original and creative contents.

In this process, students will be able to not only learn how to reason and solve problems digitally, but also to create and define new ones drawing on their creative capability and critical thinking.

Moreover, young students should understand the risks and threats that they face in the same way as the rest of the community aggravated with the fact that they spend most of their time immersed in cyberspace with the false feeling that since they are "digital natives", so at ease with technology and devices, their – frail and superficial – expertise protects them from hazards and attacks.

Qualification

AI brings enormous potential for productivity growth from agriculture to high-technology services, but it requires a qualified workforce trained to identify the best AI opportunities, develop engineering solutions, adapt current working environments, and deploy AI applications following safe and ethical standards. To this extent, a proper qualification of the workforce in ICT in general, and in AI in particular, is fundamental to enable Portuguese economic development and sustainability. Over the last couple of years, Portugal has become a very attractive place for international high-tech companies because of its secure and friendly social fabric as well as the technical quality of its workers. Moreover, it has become a fertile environment for start-ups that have taken an international stand and in various cases become first class players. But success has also shown the shortage of a qualified workforce and a very strong effort has to be made to overcome this problem.

The actions to tackle this challenge must take place at various stages:

- i) to extend the professional training of unemployed and active workers in ICT and AI, to allow them to be active agents in the application and support of AI in various industrial and service sectors. For this purpose, private companies or enterprise associations and public institutions like IAPMEI¹ and IEFP² must play an important role;
- ii) to improve the quality of public services through a better qualified public administration, the responsibility of which relies heavily on INA³;
- iii) to re-skill professionals from less employable sectors and up-skill programmers and engineers through advanced training programmes in AI and through a strong involvement of Polytechnic Institutes and Universities.

Specialisation

The Portuguese higher education system has been preparing highly skilled professionals in computer science and engineering, as well as in highly related fields like electrical and electronic engineering, communications, mathematics and physics. The intake of STEM students in Portuguese universities and polytechnic institutes is higher than the EU average. Moreover, more than half of these students pursue their studies to an MSc degree and the number of PhD programmes and students in areas related to AI and data science have steadily increased over the past decade.

At the same time, the *Lisbon Machine Learning School*, an international summer course, is almost at its 9th edition while in Porto a similar organisation on *The Future of Computation* will be in its 2nd edition this year, both of which aim at researchers and graduate students, computer scientists and industry practitioners who desire a more in-depth understanding of these subjects.

The interest in AI, data science and their application and implementation in various domains has been growing among students and academic and research staff, and the transfer of technology and solutions to industry and services is creating a bridge over the so-called "death valley".

1 IAPMEI – Portuguese Institute for Support to SMEs

2 IEFP – Portuguese Institute for Employment and Professional Training

3 INA – Portuguese Institute for Public Administration

PORTUGUESE HIGHER EDUCATION SYSTEM HAS BEEN PREPARING HIGHLY SKILLED PROFESSIONALS IN COMPUTER SCIENCE AND ENGINEERING, AS WELL AS IN STRONGLY RELATED FIELDS LIKE ELECTRICAL AND ELECTRONIC ENGINEERING, COMMUNICATIONS, MATHEMATICS AND PHYSICS

Research

Research on AI, which holds a long tradition in Portuguese academia, should also be intensified as an ample domain *per se*. Today's challenges are very diversified and complex, such as for example:

- i) improving learning methodologies like learning with small data sets and through the generalisation of outliers;
- ii) understanding context connecting each statement with everything that came before;
- iii) understanding causality and, being able to differentiate correlation and causality

But also considering ethics, one of the most challenging aspects in AI today, and building trust through data curation in order to avoid biases assuring transparency in the way judgements are made promoting accountability and explainability.

AI research also induces the development of neighbouring areas like advanced computing and the emergence of new areas like quantum or neuromorphic computing, and everything that deals with the blend of digital and the physical world. New services and industrial processes will emerge and they will certainly have a role in sustainability.



03

INTRODUCTION

Artificial Intelligence is already a powerful and transformative technology driving all sorts of changes and with a wide-ranging effect in different domains from health to education, from work and organisational cultures to the environment. The global outlook is that AI will become increasingly important for economic growth and development at least during the next five to ten years. Its promises and potential may be harnessed for the social common good and for all⁴, but it may also unleash complex risks to society. Portugal has an active and rapidly growing AI ecosystem, including academia, industry and the public sector, and must act to fully benefit from this revolution. In order to be prepared for it, Portugal must foster a strong investment in AI at national and European terms, mobilise key actors, identify key areas

for development and mitigate risks for the citizens and society.

The aim of this document is to set the basis of a national strategy for the development of the Portuguese economy and society through the use of Artificial Intelligence in public and private activities and the consolidation of fundamental and applied research on AI. This strategy is fully aligned with the Coordinated Action Plan of the EU and its Member States and it is included in INCoDe.2030, the Portuguese initiative to foster digital skills.

In 2018, Europe made a strong commitment to strengthen European Research, Development and Innovation (R&D&I) in AI in order to face an accelerated competition in the global market. With this in mind, the development of a Coordinated Action Plan on Artificial Intelligence in Europe has been launched in

The global outlook is that AI will become increasingly important for economic growth and development at least during the next five to ten years

⁴ Communication from the Commission to the European Parliament, The European Council, the Council, the European Economic and Social Committee and the Committee of the Regions – Artificial Intelligence for Europe – COM(2018) 237 final, 25.04.2018.

PORTUGAL MUST FOSTER STRONG INVESTMENT IN AI AT NATIONAL AND EUROPEAN TERMS, MOBILIZE KEY ACTORS, IDENTIFY KEY AREAS FOR DEVELOPMENT AND MITIGATE RISKS FOR THE CITIZENS AND THE SOCIETY

April 2018 and formally accepted by the Council in December 2018⁵. Recognising that AI is transforming our world and present challenges and opportunities that need to be faced with ambition and by joining forces, the Action Plan calls for a coordinated approach at European level encouraging the use of this powerful technology to help solve the world's biggest challenges, from health to climate, from transport to agriculture, and from cybersecurity to industry in general.

Portugal has joined these efforts from the first preparatory meetings so that Europe is at the forefront in investing and developing AI and in exploring the opportunities offered by AI. It is essential to scale up public and private investments and to mobilise all actors concerned around common strategic interests, from research and innovation to bringing state-of-the-art AI applications into the market so that the economy and the public sector uptake the foreseeable benefits of AI. In line with the Declaration signed by the EU Member States in April 2018⁶, Portugal wants to rise to the expectation of this ambitious European approach.

AI needs an interdisciplinary and collaborative approach. The opacity often seen around the implications of AI may be an obstacle for the wider society to make sense of it and take part in the dialogue. AI needs to integrate cognitive diversity to foster social inclusion and transformation. Therefore, we need a diversity of specialists that will foster different perspectives to better solve complex problems. But we also need the whole population to take part in the debate and to get involved in designing AI by voicing priorities of what AI should address in a human-centred approach. Championing diversity, a source of innovation, in AI brings together different forms of collective and distributed intelligence to solve problems⁷. The value of AI also relies on its ability to become democratically distributed. In order to achieve this, we need to invest in the creation of mechanisms to store, make available and distribute *data* as well as in the development of digital education and skills to citizens.

We know that AI will have, and is already having, a strong positive impact on Portugal and Europe. Albeit this technology becoming a driver for economic growth and, transforming the labour market, industry, and society as a whole, we also know that it carries *risks* that have to be identified and

mitigated so that the opportunities it brings can be fully reaped. With this in mind, Portugal's AI Strategy will be based on the fundamental principle of not compromising the dignity of citizens, strongly anchored by the promotion of *wellbeing, fairness* and quality of life.

Portugal is already active in many research, innovation and deployment projects in the field of AI particularly in regard to machine learning, multi-agent systems, big data, remote sensing, robotics, advanced analytics, augmented reality, intelligent systems, monitoring, simulation, and maintenance to name a few applied to automated manufacturing, autonomous vehicles, anomaly and fraud detection,

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⁵ Communication from the Commission to the European Parliament, The European Council, the Council, the European Economic and Social Committee, and the Committee of the Regions – Coordinated Plan on Artificial Intelligence – COM(2018) 795 final, 7.12.2018.

⁶ European Commission: <https://ec.europa.eu/digital-single-market/en/news/eu-member-states-sign-cooperate-artificial-intelligence>

⁷ Levy, P. (1997) *Collective Intelligence: mankind's emerging world in cyberspace*. Cambridge, UK: Perseus.

WE NEED A DIVERSITY OF SPECIALISTS THAT WILL FOSTER DIFFERENT PERSPECTIVES TO BETTER SOLVE COMPLEX PROBLEMS. BUT WE ALSO NEED THE WHOLE POPULATION TO TAKE PART IN THE DEBATE AND TO GET INVOLVED IN DESIGNING AI BY VOICING PRIORITIES OF WHAT AI SHOULD ADDRESS, IN A HUMAN-CENTRIC APPROACH

energy efficiency, critical infrastructures management, precision agriculture, oceans, transport, mobility, environment, and health.

Ultimately, we want to foster the **impact of AI** on transport, agriculture, energy and sustainable energy systems, aeronautics and space, security and industry in general. Other areas of the utmost importance are the blue economy, urban development and mobility, Earth Observation and biodiversity.

In **industry**, AI will completely change the paradigm of human machine interface and the decision processes based on several developments, including robots, to adapt to new working environments with little to none reprogramming needed and systems with real time control capabilities.

Acknowledging that people are the central element of research, innovation, deployment and usage of any AI manifestation, the outlined AI strategy deliberately puts at the core of its action plan the empowering of people with the necessary knowledge, skills and means to thrive in an AI enabled world.

What is AI?

Artificial Intelligence is a broad term with a large number of formal and informal definitions. For the scope of this initiative we refer to AI as the scientific area and the suite of technologies that use programs and physical devices to mimic advanced facets of human intelligence. AI artefacts can display abilities such as

(but not necessarily limited to): autonomy, problem solving, complex planning, negotiation, reasoning, inference, decision making, diagnosis, prediction, monitoring, learning from experience, adaptation to new situations, language understanding and generation, explanation, argumentation, visual/audio recognition, object recognition and the generation of complex artefacts. For this strategy, we will focus on emerging AI technologies.



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04

PORTUGAL IN TECHNOLOGY AND AI NOW



Portugal is showing good results in some innovation indicators (including but not limited to AI), although in many of them we have been typically placed below the average of the European Union⁸. Portuguese institutions are particularly well positioned in terms of international research collaborations, broadband penetration and product/process innovations in Small and Medium-size Enterprises (SME). Portugal has been relatively successful as an innovation-friendly environment and has an attractive research system.

Human Resources: Numbers from 2017 show that Portugal has a shortage of qualified human re-

sources in advanced technological areas, mostly in terms of higher education (67% of the EU average in 2017) but also in lifelong learning (88.8%) and new PhDs (94%). Employment in knowledge intensive activities is low (57% of EU) but it is slightly above average in fast-growing enterprises (103.2%).

Research: Portuguese research has a high level of international collaboration (185% of the EU average in 2017) participating in the 10% most cited works (82.6%) and in the attraction of foreign PhD students (98.3%).

Innovation: The slice of employment of fast-growing companies in the most innovative sectors has

been improving. The R&D expenditure of the business sector has considerably improved since 2015 and represents about 52% of gross expenditure in R&D. SMEs are doing quite well in innovations in the product or the process (158.8%) and in marketing/organisation levels (112%).

Infrastructure: The best indicator of Portugal in the 2018 European Innovation Scoreboard is broadband penetration (200%). Despite us having a low level of Internet usage (below 60% of the households in 2017)⁹ including e-commerce and internet banking with a better performance in the use of social networks.

⁸ "European Innovation Scoreboard 2018" and "Country Report Portugal 2018

Including an In-Depth Review on the prevention and correction of macroeconomic imbalances", COMMISSION STAFF WORKING DOCUMENT

⁹ Digital economy and digital society statistics at regional level, <https://ec.europa.eu/eurostat/statistics-explained/>

The Portuguese AI ecosystem

Portuguese universities and polytechnic institutes offer a broad range of first, second and third cycle degrees in Information Technology. The offer of MSc and PhD degrees in AI related topics is also noteworthy and growing steadily. However, companies in Portugal report a lack of human resources in these areas. The offer in post-graduate conversion courses and focused specialisations is limited but growing, most of which are carried out in co-operation with companies.

Academia hosts a good number of research centres that have been devoted to AI (including robotics) for some decades. Scientific societies have been active in the promotion of AI as a scientific and technological field. The Portuguese AI Society (APPIA), Robotics Society (SPR) and Pattern Recognition Society (APRP) are the most established in the field. Fundamental and applied research on AI has been conducted in Portugal since at least 1980 and the Portuguese AI community has since built a solid world reputation both through researchers working in Portugal as well as Portuguese doing AI research abroad. In terms of activity, Portugal ranks 21st in the world of all-time AI related scientific publications per capita¹⁰.

The increased number of new technological companies involved with AI has been impressive. Young scale-ups and delegations of European multinationals have become important in hiring (hundreds of IT and AI specialists) and development (innovation, collaboration with universities, and knowledge-intensive exports). However, a 2018 study conducted by Microsoft¹¹ reports that only 4% of the universe of 277 relevant companies consulted consider themselves to be in a mature stage of AI usage, 61% are still planning or in the pilot stage, and 57% of the companies expect AI to have a high impact on new business areas.

Collaboration between companies and academia is becoming increasingly common, both in terms of collaborative R&D as well as in the recruitment flow. However, top companies working in Portugal on AI recognise that they have to improve their competence in forging partnerships with Academia.

The Portuguese Public Sector (PPS) comprehends a very large number of entities. In 2018, the scientific funding agency (FCT) supported 19 new projects between research units and PPS entities focused on the application of AI to improve public administration. Other initiatives along the same line are prepared for 2019 with a tendency to increase the innovation indicators within the PPS.

Collaborative Laboratories (CoLABs) are a new form of partnership between industry and society for market-driven innovation and skilled job creation. CoLABs' main goals are to create qualified and scientific employment in Portugal through the implementation of R&I agendas oriented towards the creation of economic and social value eliminating the gap between research and innovation activities; reinforcing the collaboration between different institutions (public and private) in co-responsibility of knowledge-based strategies; combining public based, competitive, and private funding. There are currently 21 CoLABs¹², some of which have activities related with AI.

¹⁰ Source: www.scopus.com.

¹¹ Artificial Intelligence in Europe: Portugal, Outlook for 2019 and Beyond. Report by Microsoft

¹² https://www.fct.pt/apoios/CoLAB/docs/lista_homologada_titulo_de_colab_lote2.pdf
https://www.fct.pt/apoios/CoLAB/docs/Lista_homologada_titulo_de_CoLAB.pdf

PORTUGUESE RESEARCH HAS A HIGH LEVEL OF INTERNATIONAL COLLABORATION



These joint ventures gather academia, companies and other important stakeholders.

Portugal has three Digital Innovation Hubs (DIHs) already established and aims to enlarge the network of DIHs. These one-stop-shops help companies to become more competitive with regard to their business/production processes, products, and services using digital technologies, including AI. DIH are one of the most important pillars of the Digitise European Industry effort as they are composed of the most relevant business groups in the respective areas as well as start-ups, SMEs and academia in order to ensure the broad dissemination and transfer of know-how by and to the business community. The three DIH are Produtech (production technologies), iMan Norte Hub (manufacturing) and HUB4AGRI (agriculture).

A brief digital perspective of the Portuguese Education System

Portugal has been following an ICT strategy in education similar to some Organisation for Economic Co-operation and Development (OECD) countries with a strong investment in technology and its use. The 2015 OECD report on "Students, Computers, and Learning: Making the Connection" indicates that boys are significantly more likely than girls to start using computers early. Surprisingly, the report also observes that access to computers in schools is not a predictor of student performance. In fact, students who use computers very frequently at school do a lot worse in most learning outcomes, even when social background and student demographics is considered. The study results also show that strong investments in ICT for education produced no significant improvements in student achievement in reading, mathematics, or science. Inversely, students with a baseline level of proficiency in reading and mathematics perform better in digital competences. This context must also take into consideration the fast pace of technology change, which deprecates technology usage at the same rate and increases the risk of future adults being left with very little useful knowledge after several years of education.

According to the same OECD report, Portugal is still below average in many relevant Digital Education indicators for the preparation of youngsters for an AI world, namely the number of students who reported the use of computers in Maths lessons; differences in early exposure to computers and the Internet between boys and girls; the success rate on tasks that require the use of

computers to solve problems; performance in digital reading; and the index of ICT use at school.

However, it is noteworthy that Portugal is among the best OECD countries in the use of ICT outside of school for schoolwork while lagging behind OECD average in the use of ICT at school, which seems to support that Portuguese students are aware of the importance of ICT in education and use it as a common tool for study. This also suggests that the introduction of Computer Science contents supporting AI, possibly articulated with other disciplines, should be well received by students.

THE INTRODUCTION OF COMPUTER SCIENCE CONTENTS SUPPORTING AI, POSSIBLY ARTICULATED WITH OTHER DISCIPLINES, SHOULD BE WELL RECEIVED BY STUDENTS



The R&D expenditure of the business sector has considerably improved since 2015



AI in the world

The year 2018 was the year AI re-appeared as a practical and powerful technology with the ability to bring a significant added growth to the world economy in a short to medium term. The burst of comprehensive information systems in companies in the turn of the 90s, the almost simultaneous tremendous growth of the World Wide Web and the ubiquitous dissemination of sensors made available a huge quantity and variety of data that potentially enabled the automation of many decisions in line with the widening of the importance of robotics and automation.

THE EUROPEAN UNION SIGNED IN APRIL 2018 A DECLARATION OF COOPERATION AND ANNOUNCED THE COMMUNICATION OF "ARTIFICIAL INTELLIGENCE FOR EUROPE"

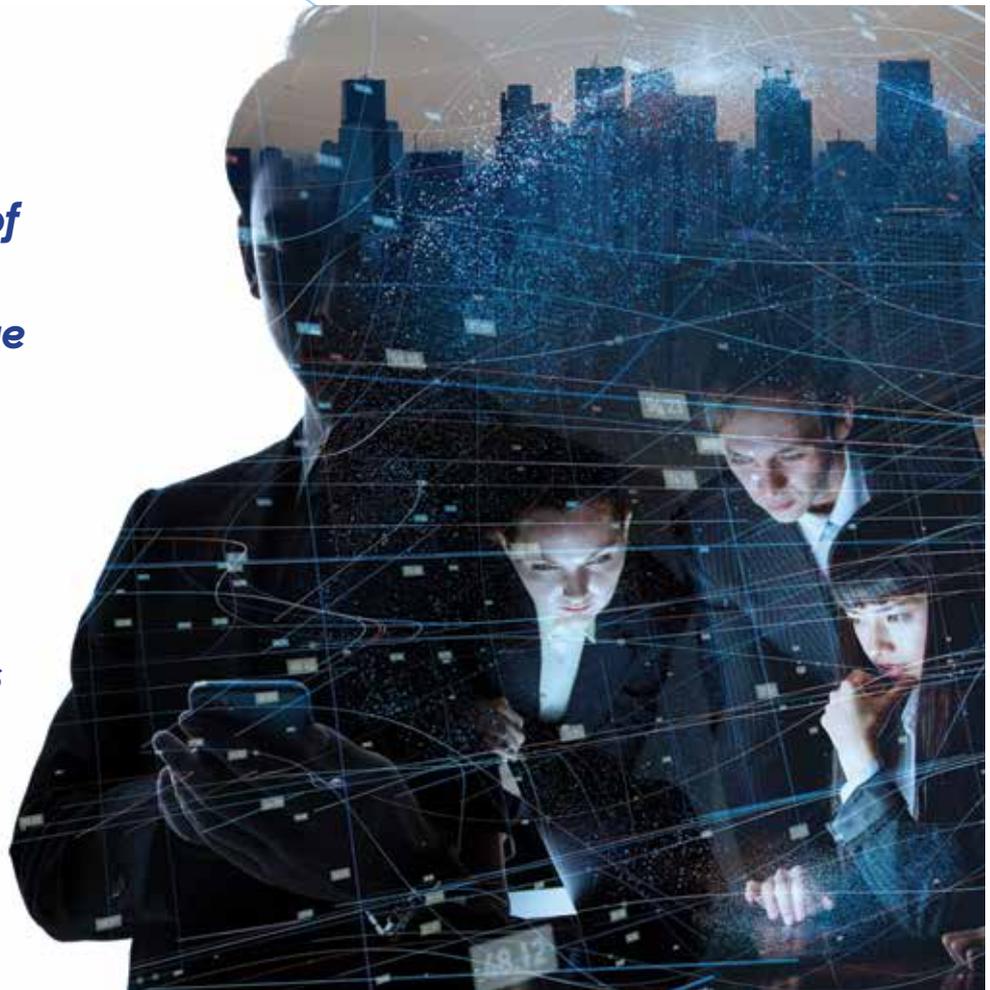
The exponentially increasing computing power and storage capacity made a small but visible fraction of this endeavour possible. The United States has been one of the main leaders of this revolution through their technological giants and top universities. US companies gather data from all over the world and

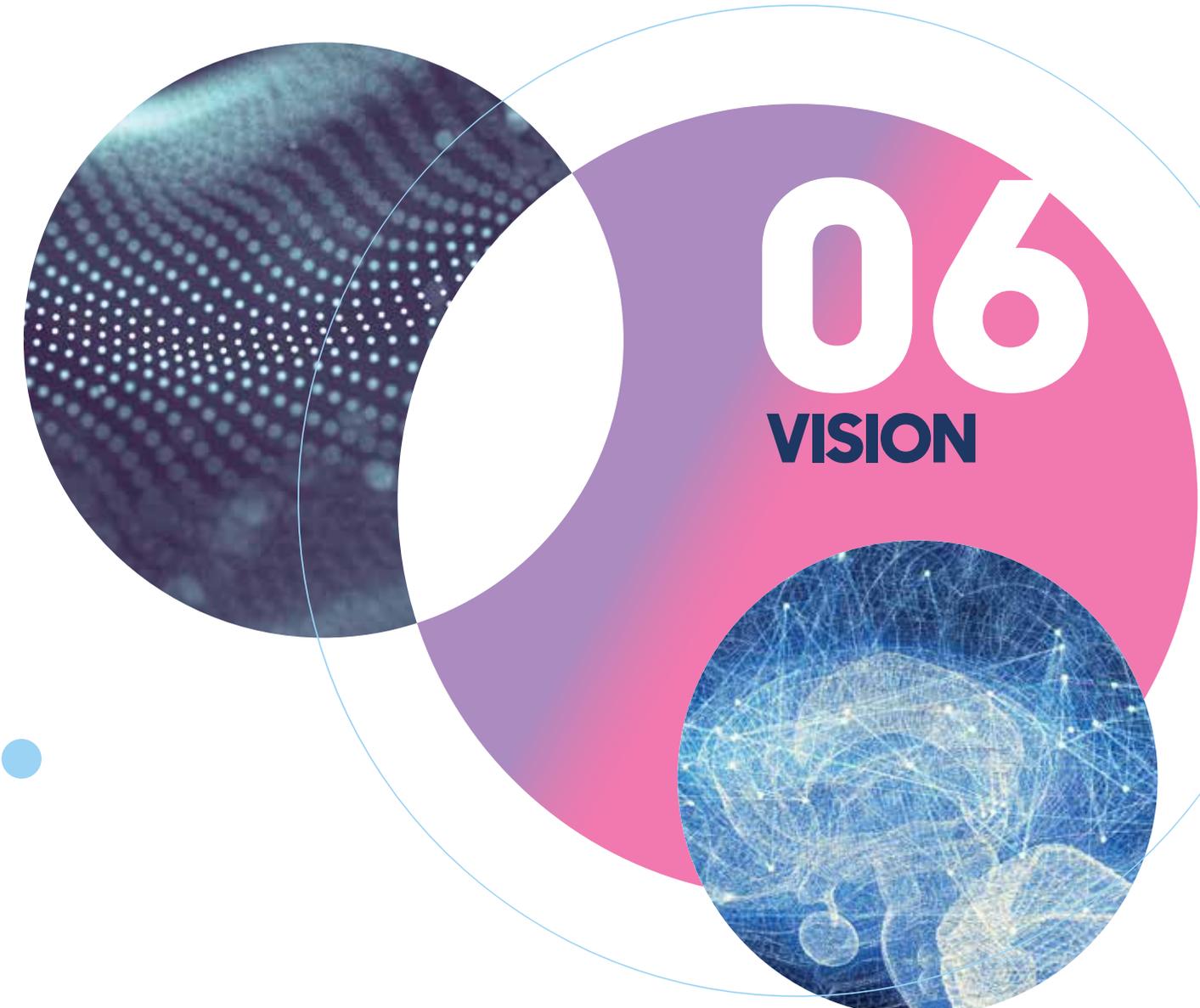
dominate electronic commerce and commodity web services. China launches their own AI strategy with the aim of being in line with the world by 2020 and to lead in some AI areas in 2025. They are highly investing in the development of skills, which is a major weakness for the Chinese ecosystem, research and industrialisation. Chinese protective information regulation provided the opportunity for their own tech giants to rise. Canada has been investing hugely in the research and development of skills fostering innovation through university-industry collaborations and attracting the offices of US tech companies. Canada is also home to some of the

The burst of comprehensive information systems in companies in the turn of the 90's, the almost simultaneous tremendous growth of the World Wide Web and the ubiquitous dissemination of sensors made available a huge quantity and variety of data that potentially enabled the automation of many decisions in line with the widening of the importance of robotics and automation

founders of deep learning, possibly the AI technology that mostly boosted the ongoing AI revolution. These researchers have recently won the prestigious Turing Award on account of their scientific contributions. France plans to invest 1.5 billion Euros on strengthening the AI ecosystem and developing an open data policy. Germany has been home to the Industry 4.0 which acknowledges the power of the digital and AI in the development of industry and economy. Finland's strategy stresses the importance of digital skills and human capital for innovation and societal development. Meanwhile, many other nations in the world have announced their own view of the roads to be taken in this AI revolution.

The European Union signed in April 2018 a declaration of cooperation and announced the communication of "Artificial Intelligence for Europe". The High-Level Expert Group was nominated shortly after that. The Group on "Digitising European Industry and AI" with representatives from all Member States and propelled by DG-Connect promoted several meetings and produced a "Coordinated Action Plan" in December 2018. The strategies of the Member States should be defined by mid-2019.





06

VISION

By 2030, Portugal will have a knowledge intensive labour market with a strong community of forefront companies producing and exporting AI technologies supported by an academia involved in high-level, fundamental and applied research. AI technologies will be easily available to promote the efficiency and quality of all activities, including SMEs, public services and every citizen. The labour force will be highly qualified and Portugal will be at the forefront of AI Education for all. AI will improve the quality of services and the efficiency of processes while guarantying fairness, wellbeing and quality of life.

Detailed Vision

Promoting a better society: AI will improve the quality of services and efficiency of processes while guarantying human dignity as well as wellbeing and quality of life. The economy will grow at a faster pace due to the adoption of AI. Important societal problems such as sustainability, resource management, and unemployment will be successfully handled using AI and data science technologies. Strong ethical guidelines will protect the fundamental rights of citizens and our core values.

Fostering AI skills and "digital minds" for all: Portugal will be at the forefront of AI Education with every student prepared with Computer Science knowledge capable of leveraging AI general skills as well as promoting specialists and attracting AI talent from Portugal and abroad. The Computer Science based strategy of AI skills and related skills will spread to earlier stages of education and to lifelong learning.

Promoting new jobs and developing an economy of AI services: All companies and public services will consume AI. A supply chain of AI services will bring AI from the research labs to society. Services will be accessible to

SMEs through the adoption of AI as a service (AI-on-demand). Specialised companies will be able to develop and adapt AI algorithms and put them in the national and international markets. A data market and a model market will flourish together with other AI-related direct and indirect markets. Portugal will adopt AI technologies at a fast pace modernising industry and the public sector and competing in the global market.

Fostering Portugal as a living lab for the experimentation of new developments:

Portuguese innovative sectors will be promoted as "living labs" for new experimentation at a global level, including in: i) AI for urban transformation through sustainable cities; ii) AI for sustainable energy networks; iii) AI for biodiversity, from forests and green economy to marine species and blue economy; iv) AI for autonomous driving; v) AI for cybersecurity; and vi) Quantum materials for AI; vii) adaptive learning curricula for students.

Securing AI niche markets through key specialised services in Portugal:

areas of specialisation will be further developed, namely: i) Natural Language Processing with application in automatic translation and other automatable services; ii) Real time AI with application in secure business and financial transactions; iii) AI for software development; iv) AI for edge-computing.

Contributing to new knowledge and developments through AI research and innovation:

AI knowledge will keep evolving rapidly over the next decade. The research community will strengthen their presence in the world through the development of edge-cutting research in cooperation with the best international research teams. The growing application of AI by Portuguese companies will motivate the development

The growing application of AI by Portuguese companies will motivate the development of innovative algorithms and methodologies, and the Portuguese AI community will participate in the development of future AI



of innovative algorithms and methodologies, and the Portuguese AI community will participate in the development of future AI.

Provide better public services for citizens and businesses, and adopt evidence-based approaches on public policies and decision-making processes:

AI and data science will become an important tool to pursue the vision laid out in the 2020 ICT Strategy changing from a reactive paradigm to an anticipatory service provision paradigm. At the same time, public policies and decision-making processes will be increasingly supported by evidence and not by intuition making use of the vast amount of administrative data already collected for operational purposes.

AI WILL IMPROVE THE QUALITY OF SERVICES AND THE EFFICIENCY OF PROCESSES, WHILE GUARANTYING THE HUMAN DIGNITY AS WELL AS WELLBEING AND QUALITY OF LIFE

07

OBJECTIVES



Our main general objectives to reach by 2030 are the following.

> **Added Economic Growth:** the added value brought by AI technologies to the economic growth should be significant.

> **Scientific Excellence:** improve the front-line position in fundamental and applied AI research of the Portuguese Academia (universities, polytechnic schools and research institutions) measured in terms of publication impact, international leaderships, and international collaborations.

> **Human Development:** Increase dramatically the qualifications of the labour force, in particular the technological qualifications, while promoting inclusion and awareness at all levels of education.

In the process we expect to observe a significant **increase in the number and volume of knowledge-intensive AI companies** displaying a considerable R&D effort and **increased collaboration between academia and companies/public sector**.

The growing application of AI must also strengthen societal robustness, by building a clear vision of the impacts of AI in democracy, privacy, security, fairness, the labour market, governmental and commercial transparency and equity

The awareness of AI capabilities and how it can be used to boost business and overall quality of services should **spread to the whole of society** including SMEs, and the public sector, as well as to citizens in their everyday life.

The growing application of AI must also strengthen **societal robustness** by building a **clear vision of the impacts of AI** on democracy, privacy, security, fairness, the labour market, governmental and commercial transparency and equity. Although AI is highly disruptive in all these dimensions it also provides, if made **ethical-by-design**, a set of powerful tools to actually improve society and democracy.



08

STRATEGY

The strategy will revolve around four main interacting processes.

> The attractiveness of Portugal for knowledge intensive young companies and international production units is high and has the conditions for improvement. These units work in different sectors but have the need for development of specialised AI software and high-tech devices for export in common. The collaboration with academia is growing in two axes: joint research uptake (joint projects and CoLabs) and the qualification pipeline.

> The development of this ecosystem will motivate the increase of the currently developing innovation levels for a vast number of companies and organisations, including start-ups, SMEs, and the Government Sector through business networking and by benefiting from the maturing collaboration platforms with academia. These include AI-on-demand pipelines and Digital Innovation Hubs. Expected outcomes include an increase in the number

of patents and the multiplication of innovation-based businesses.

> The research potential in AI and other areas will grow due to the larger share of private investment and because of the added value induced by the challenges brought by innovating companies. Moreover, researchers will gain insight into the future of AI itself as a fundamental scientific field. Expected outcomes are a higher attraction of research talent (and as a consequence of professional talent), a higher impact of scientific publications and an increased ability to join international research networks of excellence. These scientific results will in turn revert back to the productive sectors.

> Academia alone and in collaboration with the Industry will increase its capacity and develop different levels of qualification programmes in AI and related areas. Other educational institutions working at different education levels will also be motivated to invest in skilling, reskilling and lifelong learning aiming at tailored qualifications.

The attractiveness of Portugal for knowledge intensive young companies and international production units is high and has conditions to improve

The development of this ecosystem will motivate the increase of the currently developing innovation levels for a vast number of companies and organizations



As an outcome, Portugal will increase the qualification levels of its professionals and increase the level of knowledge-intensive employment.

Each of these four processes will be accelerated through the following instruments.

- > Innovation funding programmes for forefront AI-driven companies and for joint uptakes with the research community;
- > Creation of national and international sandboxes and testing facilities for the development of cutting-edge technologies;
- > Early development of knowledge-transfer platforms (Digital Innovation Hubs) that will gradually be self-sustained as well as the consolidation of an infrastructural initiative towards full digitalisation of the activities;
- > Refinement of the innovation voucher instrument;
- > Support for application based and fundamental research that will be multiplied by private funding;
- > Support and improvement of working conditions for the development of qualification programmes;

- > Creation of qualification vouchers;
- > Attraction and retention of talent through internationalisation campaigns.

At the same time, it is of the utmost importance to ensure our core values and understand the impacts of AI.

- > Define regulatory frameworks (also through the creation of regulatory sandboxes);
- > Define and deploy guidelines for ethical-by-design AI through an ethical committee for AI and Automation;
- > Spread awareness on AI and technology in the entire population to promote inclusion;
- > Study the impacts of AI on society (i.e. employment, democracy, and fairness) through focused observations and by promoting research in the respective scientific areas.

ACADEMIA ALONE AND IN COLLABORATION WITH INDUSTRY WILL INCREASE ITS CAPACITY AND DEVELOP QUALIFICATION PROGRAMS OF DIFFERENT LEVELS IN AI AND RELATED AREAS



09 ACTIONS

Areas of specialisation in Portugal with international impact

Portugal currently has strong players in some areas that may serve as inspiring examples and help drive innovation and research. The following list identifies some of these areas where Portugal will make a specific effort to lead in Europe.

Natural Language Processing

Portugal has developed an active research community in the area of computational linguistics / natural language processing as well as successful companies (i.e. Unbabel and Priberam among others). Independent language resources that can be used by the diversity of European and world languages and Portuguese in particular should be further promoted. Textual data is ubiquitous and improving its processing will have a significant impact on all domains of application.

SPECIFIC OBJECTIVES

- > Affirm international leadership in a few key areas, as listed below, by means of joint actions of companies and academia leading to innovation, edge-cutting research and involvement in international networks.
- > Increase the impact of these areas in the Portuguese economy.
- > Identify other emerging research/innovation lines of AI and related technologies.

SPECIFIC ACTIONS

- > Foster access to new and sophisticated markets worldwide;
- > Enable data and technology sharing for promoting research development and collaboration between academia and companies.
- > Enable platforms for companies and academia to share best practices.
- > Promote the availability of an adequate computing infrastructure.

Real Time decision making with AI

In many applications, AI algorithms need to respond in real time and autonomously and be able to absorb new data and adjust learned models. Data comes in volume and velocity from trading or business transactions, from sensors in automobiles or in industrial pipelines, from electrical and telecommunications networks, from interactions with the environment, from smart city installations, from robots moving in challenging environments, from cybersecurity installations, and from highly intensive games or simulation interactions. Data has to be processed fast, models have to adapt fast, and algorithms have to decide promptly and accurately. Portugal has a strong research community in data stream learning and many companies have expertise in dealing with this kind of scenario.

AI for Software Development

The effort of software development can be aided by AI. The abstraction level of programming can be increased through AI in specific domains making coding easier and accessible to a wider audience. Development can be faster and automated improving the entire software production lifecycle and reducing maintenance costs. This can also be central for the dissemination of specific domain skills in software development. This is an area where Portugal is already well equipped with a strong offer in rapid software development processes and platforms, which must continue to improve and innovate through AI.



AI for Edge-computing

Portugal can play an important role in the area of Internet of Things (IoT) and edge-computing. Industrial units produce hardware devices for different industries such as automotive, agricultural, and industrial machines and environments (i.e. for cities, factories, autonomous vehicles, and including current major firms).

Areas for research and innovation in European and international networks

In the area of AI there is relevant investment of European companies in Portugal in several domains, such as automotive, car multimedia and intermodal transports; information systems; components and services for 5G networks; smart cities and security; banking; and bioeconomy and biorefineries. Some outstanding examples with companies, researchers and joint ventures already in action are referred hereafter.



The effort of software development can itself be aided by AI. The abstraction level of programming can be increased through AI in specific domains, making coding easier and accessible to a wider audience

SPECIFIC OBJECTIVES

- > Make AI research have an economic and social impact on all the referred areas with emphasis on the subjects mentioned below.
- > Have a strong research driven ecosystem of companies, academia, public sector and society including start-ups, scale-ups, and established companies.
- > Guarantee that AI is safely and ethically applied to the various domains.
- > Help companies and regulators find appropriate legal frameworks.
- > Identify strategic lines of research that can foster the long-term future of AI.

SPECIFIC ACTIONS

- > Identify KPI for AI investment evaluation in Portugal.
- > Set up DIHs focusing on AI, working in close collaboration or integrated with the existing sectorial DIH already in the field and with European DIH (for example the DIH on cybersecurity at Leon or the DIH on IoT in Salamanca).
- > Set up one or more AI-on-demand platforms linked to other similar efforts in Europe to be made available through DIH.
- > Promote innovation vouchers and those that facilitate industry-academia cooperation.
- > Further promote the participation in the European effort for developing regulation and protocols for an Ethical and Secure AI.
- > Develop regulatory sandboxes articulated with the EU.
- > Foster the collaboration between companies in Portugal and European industrial giants through participation in European Networks.
- > Integrate a strategy of closer cooperation between European AI excellence centres around agendas fixed together with industry and based on common knowledge and common challenges for the deployment of AI-based solutions in the areas where Europe faces major challenges;
- > Engage with international partners in order to align positions and benefit from international cooperation in AI, including with Africa, in a variety of areas not forgetting subjects such as standards, ethics and cybersecurity. Informed and concerted actions in AI are required and international cooperation is essential in all activities for a responsible and concerted development of AI.
- > Reinforce the national structure for funding management.

AI and urban transformation through sustainable Cities

Smart cities will rely more and more on AI. Be it in the use of big data, software application in all aspects of life in the city (i.e. traffic control and public safety), or energy efficiency and autonomous vehicles and logistics, the city will embed AI in order to optimise and adapt these technologies to the inherent rapid changing environment in a complex ecosystem that is a city. The development of smart cities

relies on research, on education and skills, on innovation, and on the market uptake of new technologies. AI is fundamental for urban transformation and many leading projects in Portugal are already pursuing these challenges from car multimedia to cyber security.

AI and sustainable energy systems

Current debates and trends in energy, both within Portugal and the EU, highlight some significant en-

ergy system challenges. The first of these is the need to reverse the energy consumption and emission trends most nations have seen over the past 15 years. Meeting greenhouse gas emission targets is a challenge that calls for new ideas, tools, technologies, and policies.

It is essential to devise strategies for meeting these challenges in a cost-effectively manner requiring intelligent energy management systems as well as new energy system methodologies that capture the dynamics and driver

AI APPLIED TO BIODIVERSITY HAS ALSO AN ENORMOUS POTENTIAL IN PORTUGAL, FROM MARINE SPECIES AND HEALTHY OCEANS IN A BLUE ECONOMY TO FORESTS FOR A GREEN ECONOMY FOR EUROPE

demands – including consumer behaviour, energy resources (especially renewable resources), and the networks that connect the two. It is also of prime importance to engage industry and governments in innovative research programmes to develop standard approaches, methods, and policies for improving the long-term performance of the energy sector while addressing climate change and energy security concerns.

Digital transformation is reshaping the energy industry with an increased use of renewables, resiliency issues and sustainability concerns to name a few, where digitisation and AI enable that change, i.e. real time data analytics to improve efficiency; distributed generation; and sensors. Digital transformation together with IoT offers both a short and long-term solution to coping with varying regulatory and pricing demands of the energy market and managing costs, uptime and service predictably.

AI, environment and biodiversity: from forests and green economy to marine species and blue economy

AI applied to biodiversity also has an enormous potential in Portugal, from marine species and healthy oceans in a blue economy to forests for a green economy for Europe, this is a cutting-edge area where we want to make a difference.

Intelligent data-driven systems applied to precision agriculture, remote sensing and Earth Observation are showing their added value in new relevant projects.

In many of these fields, the *Atlantic International Research Centre (AIR Centre)* can play a determinant role. The AIR Centre is a knowledge & data driven long-term multilater-

al platform for scientific and technological cooperation in the Atlantic towards a holistic, integrative and systemic approach to knowledge in space, oceans, climate change impacts, energy and data science. The AIR Centre is meant to become a knowledge and data driven network organisation, enabling innovative work through bottom-up initiatives that will face new and greater challenges and R&D gaps and Innovation. The AIR_DataNet, a cross-cutting initiative, is a supercomputing network of facilities and expertise supporting advanced and complex simulation models of the ocean and atmosphere and large sets of data including the Atlantic Data Cube and Atlantic GEOSS, two complementary data access tools focused on the Atlantic Ocean.

In addition, a new Fraunhofer Portugal Research Centre on precision agriculture will soon be operational and will conduct research in this field.

AI, mobility and autonomous driving

Intelligent transport will also open enormous possibilities in AI expertise. The ultimate goal is to foster the impact of AI in the industry and transportation sector by creating new jobs through introducing real-time itinerary mapping based on traffic conditions and autonomous driving capabilities. The combination of AI with the increasing communication capabilities of vehicles to interchange information with other vehicles and road and Internet infrastructure systems combined with vehicle surrounding perception will allow for a fully Intelligent Transport System (ITS) able to improve safety, reduce traffic congestions, enhance the experience of drivers, and achieve the sustainability of transportation.

AI and cybersecurity

Cybersecurity is increasingly important in a society with growing prevalence of information systems, many of which have AI. An increasing number of these systems will be in control of critical facilities and infrastructures, which provide essential services to all citizens, such as hospitals, power plants, water purification and provisioning systems, transport, and integrated urban management systems. Others will be ubiquitous in smaller units such as cars and other vehicles, industrial robots and mobile robotic assistants. Cybersecurity algorithms will require the ability to adapt to new kinds of attacks and respond accordingly and autonomously in real time. Moreover, AI will minimise the elapsed time between the detection of an attack and the system's corresponding reaction. Nevertheless, AI systems can be subject to security attacks giving rise to a new and higher level set of autonomous cybersecurity management practices.

AI and health

Ambient Assisted Healthcare can benefit enormously from AI and AI applications. Big data and data sharing are essential tools and there is a significant potential for AI to deliver benefits in this sector, such as by discovering new drugs, reducing costs, diagnosing diseases, improving patient care, personal medicine and public health.

Ambient Assisted Living (AAL) is one specific area where AI can play an essential role, particularly in the support of ageing. AAL Fraunhofer Portugal¹³ currently materialises itself through the Fraunhofer Portugal Research Centre for Assistive Information and Communication Solutions (AICOS), with consolidated competences in Human-Centred Design, AI and Cyber-Physical Systems.

AI and Industry

Industry 4.0 is an important movement based on the digitalisation of industrial processes. AI plays a crucial role in the monitoring, maintenance and autonomous operation of industrial processes. Portugal has success stories in the digitalisation of sectors such as the shoe industry. The use of AI will enable a much quicker spread of efficient management tools for industries. A very relevant initiative is the Portugal i4.0 program, which has been officially launched by the Ministry of Economy with the aim of fostering the uptake of technology in the Portuguese industry, internationally promote Portuguese technological companies and attract investment.

Fundamental research for the Future AI

Despite the essential importance of application areas and domains of

specialisation, it is fundamental research that enables the necessary openness of horizons that help shape the future of AI. Companies and the Public Sector drive the pull of technologies, but academia has the responsibility of promoting the push of new ideas and technologies yet to be proven. Many fundamental research areas can be listed, some of them already have a tangible scope of application, while others are motivated by true scientific vision. Important research lines are emerging, such as: **Transparent AI**: giving algorithms the ability to explain their own decisions and provide a high level and adaptive account of their workings to promote fairness and accountability; **Emotional AI**: algorithms will utilise emotions to achieve better decisions; **Autonomous AI**: important not only in the automotive sector but also in information systems, cybersecurity, smart cities, industry, etc.; **AutoML**: intelligent systems that can use machine learning autonomously; **Computational Creativity**: producing and creating artistic output is nowadays mostly confined to human action. However, there are already good examples, which indicate that machines will have a role to play in the cultural industry as well; **Computational Ethics**: machines that can acquire, learn, discuss and adapt moral principles through algorithmic procedures.

SPECIFIC OBJECTIVES

- > To promote the excellence of fundamental science.
- > To increase the impact of Portuguese research on AI.
- > To increase the number of ERC grants on AI brought to Portugal by candidates working in Portugal.
- > To take new technologies for the industry and create new industries.

SPECIFIC ACTIONS

- > Foster the development of joint projects, ERC grants and networks on emergent AI research topics.
- > Influence Scientific European Policy towards the definition of challenging calls for scientific projects.
- > Foster the long-term collaboration between companies and academia through framework-contracts.
- > Participate in the European endeavour to develop a network of centres of excellence for AI R&D in close cooperation with a wider spread of digital innovation hubs to ensure AI takeup;
- > Strengthen the participation in the ongoing partnerships between the Member States and the EU through joint undertakings such as Electronic Component and Systems for European Leadership (ECSEL), for electronic components and systems, EuroHPC-JU the European High Performance Computing Joint Undertaking (EuroHPC-JU), for high-performing computing, and the Quantum Flagship under the Research and Innovation Programme Horizon 2020, key to processing big data and sustain further developments in AI;
- > Lead and participate in proposals for European cross-border Projects of Common Interest (energy area).

¹³ AAL Fraunhofer Portugal: www.fraunhofer.pt.

Public administration and its modernisation

The programme aims to support R&D activities that contribute to strengthen scientific and technological competencies to deal with the vast amounts of data generated in Public Administration. The goal is to use and combine this administrative data with data from other sources to better inform our public policies and decision-making processes, which should be increasingly supported by evidence and not by intuition. And, ultimately, to change public service provision from a reactive paradigm to an anticipatory paradigm.

It will contribute to the appropriation and incorporation of scientific knowledge to support operational decision systems and to enable the production of new knowledge with the goal of finding solutions for particular and real problems in public entities in order to address relevant issues for citizens in any area of governance.

Currently 19 R&D projects are being funded through the "FCT's Mobilising programme to foster AI in public administration": four initial pilot projects aim to support already established and mature partnerships between the R&D community and public administration; 15 additional projects were selected by an independent scientific panel under a specific call aiming to identify and foster new partnerships. A second call promoted by the FCT and a dedicated call promoted within the System to Support the Modernisation and Capacitation of Public Administration (SAMA2020) will fund more projects in 2019.

These 19 ongoing projects result from the cooperation between scientific institutions and entities of the public administration and are being developed under the innovation axis of INCoDe.2030 (National Digital Competencies Initiative). They cover several governance areas such as health, education, transportation and urban mobility, economic activity and land use planning.

Qualification and specialisation

Qualification and Specialisation, two INCoDE axes, are key to the development of AI driven innovation and economy in Portugal. To qualify human resources at different levels (professional courses, bachelors, masters, post-graduate specialisations, PhD and post-doc) is a challenge for a number of different reasons despite the excellent quality of both our institutions and students. Most importantly, skills are related to ICT in general and AI skills in particular, including data science. However, other supporting skills will be important as well.

Portugal is increasingly chosen as a setup point by international technological companies while national IT firms show a tremendous growth in size and number (new ICT companies have doubled per year from 2007 to 2017). Moreover, non-IT companies hire more and more staff with ICT skills. Even though Portugal is close to the European average in terms of digital competences (15th in the DESI 2017 Index, Digital Economy and Society Index of the European Commission), it needs to reinforce ICT competences. This applies to specialists, who need to be able to make the most of the growing availability of jobs in the digital market, but also to the entire human capital, increasing for example internet usage levels, which are still worryingly low.

SPECIFIC OBJECTIVES

- > Make administrative data easier for research units and, public and private to access providing a secure access and respecting personal privacy issues;
- > Continue to foster collaboration between public sector entities, businesses and research units concerning the use of AI;
- > Promote new and innovative solutions for administrative simplification, namely under the SIMPLEX program;
- > Reinforce public sector skills and capabilities with respect to AI and data science;
- > Assure the ethical use of AI in public administration;

SPECIFIC ACTIONS

- > Develop a National Data Infrastructure managed by the National Statistics Office (INE - Instituto Nacional de Estatística), which will constitute a centralised repository for administrative data;
- > Continue to fund collaborative projects between the public sector and research units to develop administrative modernisation innovative solutions;
- > Create a Collaborative Laboratory for AI in the Public Administration led by a public sector organisation;
- > Reinforce already existing AI and data science skill qualification programmes within the public sector in collaboration with Higher Education Institutions;
- > Include public sector organisations in the ethics committee for AI;

Portugal offers a training infrastructure as well as the human potential capable of being (re)qualified to meet the demands of employment opportunities that are typical of modern societies such as Portugal. However, this (re)qualification is a demanding task that requires mobilisation and a combination of efforts from different areas of governance and civil society. Digital competences are also intrinsically linked to employability - increasing digitalisation in the labour market requires new competences but offers a wider range of opportunities. A more skilled active population generates more jobs as well as innovative markets and products generating more competitive and robust economic activities.

At the same time, the country itself must be an active agent in the global effort to produce new scientific computing knowledge and develop the capacity to manage and use large amounts of information. This will help ensure a better position in Europe and in the world. We cannot wait to find out what the new technologies will be; we have to create them and work with them.

Qualification in exploiting AI is, for example, the cornerstone of Industry 4.0. Both specialisation and research have to deal with advanced AI techniques and solutions mastering them at a theoretical and technological level, developing and implementing new solutions in many different areas, such as health, space, maritime, industry, agriculture, cities, services and mobility, to name a few.

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SPECIFIC OBJECTIVES

- > Increase the overall number of human resources qualified in ICT in general and in AI in particular at the different levels of education, including short cycles for initial training and adult training, as well as graduate education/specialisation for adults.
- > Enable the development of transferable skills in academia to industry through their effective acquisition by learners in the former, in close cooperation with companies and the public administration.
- > Increase the participation of women in technological areas, namely in ICT in general and AI in particular, and thus augment the potential of the human capital.
- > Promote the attractiveness of Portugal to foreign talent, including students, researchers and experienced professionals, and reduce border obstacles when justified.
- > Promote the experimentation of new AI ideas and concepts in Portugal, including forms of cooperation among national and international higher education institutions and firms or the public administration.

SPECIFIC ACTIONS

- > Develop qualification at the regional level, including higher education institutions and local, public and private actors in the form of "Regional/local Networks for Digital Qualification" following the ongoing experience in the development of short cycles in Polytechnics, but further promoting adult training for reskilling and upskilling actions (i.e. Switch, Acertar o Rumo, Apostar em TI). It should consider the development of focused intensive courses for reskilling in close cooperation with companies and the private and public sectors;
- > Further promote the development of graduate specialisation programmes (MSc and PhD) including executive education for adults in close cooperation with firms and the public administration.
- > Launch a series of E-Learning courses covering fundamental aspects of AI and specific application domains leveraging on the results from Fundação para a Computação Científica Nacional (FCCN)'s project NAU.
- > Foster international AI and ICT talents to come study and/or work in Portugal, including ongoing actions through the "Study and research in Portugal" initiative.

Inclusion and Education: disseminating generalist knowledge on AI

Digital Inclusion and Education for all is an essential component of AI development. More extensive knowledge and skills will facilitate an adaptation to changes in professions. Opportunities for expanding qualification contents will be integrated in education programmes. The aim is to avoid highly specialised competence in an excessively narrow field.

Digital Inclusion and Education are two main axes of the INCoDe.2030 working towards securing a prominent place in terms of digital skills until the end of the next decade.

Digital inclusion

Digital Inclusion actions and projects may consider the development of CCDIs taking into account progress experience in some Portuguese regions within the context of INCoDe.2030. Each project needs to serve specific purposes in terms of local and institutional requirements.

Education

Portugal needs to change its digital education strategy from the use of ICT technology to the understanding of its fundamental Computer Science elements. This knowledge will empower students to approach a wide variety of problems by developing new digital solutions as well as providing the necessary basis to support the introduction of AI contents.

Performing this change in the digital education paradigm in schools can only be accomplished by a new initiative totally devoted to promoting change and new practices among

teachers in line with the shift from ICT use to Computing competence (i.e. motivate new networks, communities of practice, and grassroots organisations) involving, first and foremost, current ICT teachers, school headmasters, the government, academia and private companies and institutions that understand and share the importance of this change and are available to support it in different ways. The beginning of such a movement is of the utmost importance to prepare future generations for not only dealing with but striving in a digital and AI world.

SPECIFIC OBJECTIVES

- > Use ICT to change digital education.
- > Provide the necessary basis for education in AI.
- > Disseminate STEM knowledge.
- > Promote early acquisition of coding skills.

SPECIFIC ACTIONS

- > Organisation of workshops involving National stakeholders (ICT teachers, school headmasters, government officials, academia and interested private sector organisations) and international experts from the different aspects of the project.
- > Preparation of support material and digital infrastructure in collaboration with *Ciência Viva* with the help of national and international experts and organisations with proven experience: Creation of a computing study program for each level of education integrated with the study programs for other subjects; development of classroom material: classroom activities, schemes of work and evaluation methodologies; development of a digital platform for communication with and between all stakeholders, namely for the publication and discussion of classroom material and activities, national and local events, discussion fora, and online (auto)evaluation of teachers and students.
- > Specification of an online evaluation platform for students comprehending a common corpus of questions and tracking results for *ex post* analysis.
- > Promotion of the entire initiative by traditional and digital media.
- > Teaching young students the fundamentals of machine learning replicating actions already under way i.e. in some *Ciência Viva* schools, among others) in schools and in "Science Clubs" (forming trainers that replicate the work in progress).
- > Development of creative / collaborative multimedia content on science through for example networking actions bringing together schools and several Science Clubs for collaborative video creation on key STEM (Science, Technology, Engineering and Mathematics) subjects.
- > Development of programming/coding capabilities by involving teams of academia to develop a platform in which schools and Science Clubs can launch their own Coding Fests allowing for more events to be held during the year. Students will be able to learn not only how to solve problems but also how to create and define problems drawing on their creative capability.

New developments and supporting areas in European and international networks

Advanced computing: supercomputing

Portugal is actively engaged in contributing for an effective European strategy on advanced computing. We wish to be an active contributor to the EuroHPC future ecosystem in parallel with our activities in grid and distributed computing. For this purpose, we are currently conducting the installation of a new supercomputer facility optimised to support a large spectrum of relevant critical areas such as artificial intelligence, deep learning, digital modelling and data science, either in close association with the development of frontier research areas or the development of new applications and markets in a range of sectors, including Atlantic Interactions, Energy systems and services, Earth Observation and new space, precision agriculture and smart farming, health systems, and public administration and services, among others. These would be the driving objec-

tives of the new system. As such, we envisage that a multi-platform system may be the best option in order to accommodate a broad range of applications.

Existing facilities are: the Minho Advanced Computing Centre (MACC); the recently opened Advanced Computing Centre of the University of Coimbra (UC-LCA) and the C4 – Competence Centre in Cloud Computing¹⁴.

Quantum materials and quantum computing

Quantum computing and quantum materials are another challenge we want to embrace.

The International Iberian Nanotechnology Laboratory (INL), located in Braga, hosts the Quanta Lab and the Academic Hub of the IBM Q Network. INL is the only Intergovernmental Research Organisation in the world within the field of Nanotechnology with a modern and well-equipped laboratory encompassing possibilities to study and fabricate everything from DNA-chips to electronics and sensors in

¹⁴ C4 – Competence Centre in Cloud Computing: <http://c4.ubi.pt>

a complete and true interdisciplinary way with capacity to make pilot production of proof-of-concepts. Their strong interdisciplinary research integrates most scientific fields such as physics, electronics, biology, mathematics, pharmacy, and medicine. AI is a cornerstone of the INL R&D Strategy.

Facing societal challenges brought by AI: Ethics and safety

AI systems will make important and critical decisions autonomously. Society will demand transparency (the ability to explain the decisions) and audibility (the ability to trace the flow of decisions and actions from humans to algorithm) in order to promote safety and ethical principles, including privacy protection and fairness. We will need best practices to assess AI projects in terms of risks to safety and ethics and mechanisms to detect and prevent misuse of advanced AI techniques. The legal framework will have to be adjusted to determine liability in conflicts with the involvement of AI decision making.



This document's life cycle

The strategy will be monitored by a Committee coordinated by FCT (Fundação para a Ciência e Tecnologia) and this supporting document will be annually reviewed.



AI PORTUGAL 2030

PORTUGUESE NATIONAL
INITIATIVE ON DIGITAL SKILLS

An innovation and growth strategy
to foster Artificial Intelligence in
Portugal in the European context