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Artificial Intelligence for Europe

{SWD(2018) 137 final}

1. INTRODUCTION – EMBRACING CHANGE

Artificial intelligence (AI) is already part of our lives – it is not science fiction. From using a virtual personal assistant to organise our working day, to travelling in a self-driving vehicle, to our phones suggesting songs or restaurants that we might like, AI is a reality.

Beyond making our lives easier, **AI is helping us to solve some of the world's biggest challenges: from treating chronic diseases or reducing fatality rates in traffic accidents**[1] **to fighting climate change or anticipating cybersecurity threats**.

In Denmark, AI is helping save lives by allowing emergency services to diagnose cardiac arrests or other conditions based on the sound of a caller's voice. In Austria, it is helping radiologists detect tumours more accurately by instantly comparing x-rays with a large amount of other medical data.

Many farms across Europe are already using AI to monitor the movement, temperature and feed consumption of their animals. The AI system can then automatically adapt the heating and feeding machinery to help farmers monitor their animals' welfare and to free them up for other tasks. And AI is also helping European manufacturers to become more efficient and to help factories return to Europe.[2]

These are some of the many examples of what we know AI can do across all sectors, from energy to education, from financial services to construction. Countless more examples that cannot be imagined today will emerge over the next decade.

Like the steam engine or electricity in the past, AI is transforming our world, our society and our industry[3]. Growth in computing power, availability of data and progress in algorithms have turned AI into one of the **most strategic technologies of the 21st century**. The stakes could not be higher. **The way we approach AI will define the world we live in**. Amid fierce global competition, **a solid European framework is needed**.

What is artificial intelligence?

Artificial intelligence (AI) refers to systems that display intelligent behaviour by analysing their environment and taking actions – with some degree of autonomy – to achieve specific goals.

AI-based systems can be purely software-based, acting in the virtual world (e.g. voice assistants, image analysis software, search engines, speech and face recognition systems) or AI can be embedded in hardware devices (e.g. advanced robots, autonomous cars, drones or Internet of Things applications).

We are using AI on a daily basis, e.g. to translate languages, generate subtitles in videos or to block email spam.

Many AI technologies require data to improve their performance. Once they perform well, they can help improve and automate decision making in the same domain. For example, an AI system will be trained and then used to spot cyber-attacks on the basis of data from the concerned network or system.

[1] It is estimated that around 90% of road accidents are caused by human errors. See Commission's report on Saving Lives: Boosting Car Safety in the EU (COM(2016) 0787 final).

[2] Why AI is the future of growth, Accenture, 2016. The economic impact of the automation of knowledge work, robots and self-driving vehicles could reach between EUR 6.5 and EUR 12 trillion annually by 2025 (including improved productivity and higher quality of life in ageing populations). Source: Disruptive technologies: Advances that will transform life, business, and the global economy, McKinsey Global Institute, 2013.

[3] AI is part of the Commission's strategy to digitise industry (COM(2016) 180 final) and a renewed EU Industrial Policy Strategy (COM(2017) 479 final).

The European Union (EU) should have a **coordinated approach** to make the most of the opportunities offered by AI and to address the new challenges that it brings. **The EU can lead the way in developing and using AI for good and for all**, building on its values and its strengths. It can capitalise on:

- **world-class researchers, labs and startups**. The EU is also strong in **robotics** and has **world-leading industry**, notably in the transport, healthcare and manufacturing sectors that should be at the forefront of AI adoption;
- the **Digital Single Market**. Common rules, for example on data protection and the free flow of data in the EU, cybersecurity and connectivity help companies to do business, scale up across borders and encourage investments; and
- a **wealth of industrial, research and public sector data** which can be unlocked to feed AI systems. In parallel to this Communication, the Commission is taking action to make data sharing easier and to **open up more data – the raw material for AI – for re-use**. This includes data from the public sector in particular, such as on public utilities and the environment, as well as research and health data.

European leaders have put AI at the top of their agendas. On 10 April 2018, 24 Member States[4] and Norway committed to working together on AI. Building on this **strong political endorsement**, it is time to make significant efforts to ensure that:

- **Europe is competitive in the AI landscape**, with bold investments that match its economic weight. This is about supporting research and innovation to develop the next generation of AI technologies, and deployment to ensure that companies – in particular small and medium-sized enterprises which make up 99% of business in the EU – are able to adopt AI.
- **No one is left behind in the digital transformation**. AI is changing the nature of work: jobs will be created, others will disappear, most will be transformed. Modernisation of education, at all levels, should be a priority for governments. All Europeans should have every opportunity to acquire the skills they need. Talent should be nurtured, gender balance and diversity encouraged.
- **New technologies are based on values**. The General Data Protection Regulation will become a reality on 25 May 2018. It is a major step for building trust, essential in the long term for both people and companies. This is where the **EU's sustainable approach to technologies** creates a competitive edge, by embracing change on the basis of the Union's values[5]. As with any transformative technology, some AI applications may raise new ethical and legal questions, for example related to liability or potentially biased decision-making. The EU must therefore ensure that AI is developed and applied in an appropriate framework which promotes innovation and respects the Union's values and fundamental rights as well as ethical principles such as accountability and transparency. The EU is also well placed to lead this debate on the global stage.

This is how the EU can make a difference – and be the champion of **an approach to AI that benefits people and society as a whole**.

[4] Austria, Belgium, Bulgaria, Czech Republic, Denmark, Estonia, Finland, France, Germany, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, United Kingdom.

[5] Article 2 of the Treaty on EU: "The Union is founded on the values of respect for human dignity, freedom, democracy, equality, the rule of law and respect for human rights, including the rights of persons belonging to minorities". The Member States share a "society in which pluralism, non-discrimination, tolerance, justice, solidarity and equality between women and men prevail."

Launching a European initiative on AI

In May 2017, the Commission published its mid-term review of the Digital Single Market strategy[6]. It highlighted the importance of building on Europe's scientific and industrial strengths, as well as on its innovative startups, to be in a leading position in the development of AI technologies, platforms, and applications.

The European Council of October 2017 stated that the EU needs a sense of urgency to address emerging trends such as AI "while at the same time ensuring a high level of data protection, digital rights and ethical standards" and invited "the Commission to put forward a **European approach to artificial intelligence**".[7] The European Parliament made wide-ranging recommendations on civil law rules on robotics and the European Economic and Social Committee has also issued an opinion on the topic.[8]

This Communication sets out a European initiative on AI, which aims to:

- **Boost the EU's technological and industrial capacity and AI uptake across the economy**, both by the private and public sectors[9]. This includes investments in research and innovation and better access to data.
- **Prepare for socio-economic changes** brought about by AI by encouraging the modernisation of education and training systems, nurturing talent, anticipating changes in the labour market, supporting labour market transitions and adaptation of social protection systems.
- **Ensure an appropriate ethical and legal framework**, based on the Union's values and in line with the Charter of Fundamental Rights of the EU. This includes forthcoming guidance on existing product liability rules, a detailed analysis of emerging challenges, and cooperation with stakeholders, through a European AI Alliance, for the development of AI ethics guidelines.[10]

All this requires **joining forces**. Building on the approach set out in this Communication and the declaration[11] of cooperation signed by 24 Member States on 10 April 2018, the Commission will work with **Member States on a coordinated plan on AI**. The discussion will take place in the framework of the existing European platform of national initiatives to digitise industry, with the view to **agree this plan by the end of 2018**. The main aims will be to maximise the impact of investments at EU and national levels, encourage synergies and cooperation across the EU, exchange best practices and collectively define the way forward to ensure that the EU as a whole can compete globally.

In the coming weeks the Commission will issue a Communication on the future of connected and automated mobility in Europe and a Communication on the future research and innovation ambitions for Europe. AI will be a key element of these initiatives.

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[6] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2017:228:FIN
[7] http://data.consilium.europa.eu/doc/document/ST-14-2017-INIT/en/pdf
[8] European Parliament resolution with recommendations to the Commission on Civil Law Rules on Robotics (2015/2103(INL)); European Economic and Social Committee opinion on AI (INT/806-EESC-2016-05369-00-00-AC-TRA).
[9] AI can significantly improve public services and contribute to the objectives set out in the Ministerial Declaration on eGovernment – the Tallinn Declaration (October 2017, https://ec.europa.eu/digital-single-market/en/news/ministerial-declaration-egovernment-tallinn-declaration). For example, the Commission will look into AI's potential to analyse large amounts of data and help check how single market rules are applied.
[10] Building on the work of the European Group on Ethics in Science and New Technologies
[11] https://ec.europa.eu/digital-single-market/en/news/eu-member-states-sign-cooperate-artificial-intelligence

2. THE EU'S POSITION IN A COMPETITIVE INTERNATIONAL LANDSCAPE

Most developed economies recognise the game-changing nature of AI and have adopted different approaches which reflect their own political, economic, cultural and social systems.[12]

The government of the United States presented an AI strategy and invested around EUR 970 million in unclassified AI research in 2016. With its 'Next Generation Artificial Intelligence Development Plan', China is targeting global leadership by 2030 and is making massive investments.[13] Other countries, such as Japan and Canada, have also adopted AI strategies.

In the United States and in China, large companies are significantly investing in AI and are exploiting large amounts of data.[14]

Overall, **Europe is behind in private investments** in AI which totalled around EUR 2.4-3.2 billion in 2016, compared with EUR 6.5-9.7 billion in Asia and EUR 12.1-18.6 billion in North America.[15]

It is therefore crucial that the EU continues its work to **create an environment that stimulates investments** and uses public funding to leverage private investments. To do so, the EU needs to **preserve and build on its assets**.

Europe is home to a **world-leading AI research community**, as well as innovative **entrepreneurs** and **deep-tech startups** (founded on scientific discovery or engineering).[16] It has a **strong industry**, producing more than a quarter of the world's industrial and professional service robots (e.g. for precision farming, security, health, logistics)[17], and is leading in manufacturing, healthcare, transport and space technologies – all of which increasingly rely on AI. Europe also plays an important role in the development and exploitation of platforms providing **services to companies and organisations (business-to-business)**, applications to progress towards the "intelligent enterprise" and e-government.

One of the main challenges for the EU to be competitive is to **ensure the take-up of AI technology across its economy**. European industry cannot miss the train. Only a fraction of European companies have already adopted digital technologies. This trend is particularly acute in small and medium-sized businesses. In 2017, 25% of EU large enterprises and 10% of small and medium-sized enterprises used big data analytics. Only one in five small and medium-sized enterprises was highly digitised, while one third of the workforce still does not possess basic digital skills.[18] At the same time, the benefits of adopting AI are widely recognised. For example, the 2018 Digital Transformation Scoreboard shows that businesses

[12] See also the Commission's European Political Strategy Centre's Strategic Note: The Age of Artificial Intelligence, 2018.
[13] Recent announcements include a EUR 1.7 billion AI technology park in Beijing.
[14] With 1.4 billion mobile phone subscriptions and 800 million internet users – more than the USA and the EU combined – Chinese people generate vast amounts of personal data that are used to develop related AI products.
[15] 10 imperatives for Europe in the age of AI and automation, McKinsey, 2017.
[16] Europe accounts for the largest share of top 100 AI research institutions worldwide. 32 research institutions in the global top 100 for AI-related research paper citations vs 30 from the USA and 15 from China. Source: Atomico, State of European Tech, 2017. It can also be noted that the German Research Centre for Artificial Intelligence (DFKI) founded in 1988 is one of the world's largest research centres in the field of AI.
[17] World Robotics 2017, International Federation of Robotics. Europe is home to three of the world's largest producers of industrial robots (KUKA, ABB and Comau).
[18] https://ec.europa.eu/digital-single-market/digital-scoreboard. According to McKinsey (2016), European companies operating at the digital frontier only reach a digitisation level of 60% compared to their US peers.

in the agrifood and construction sectors which have adopted AI confirm positive impacts on entering new markets, improving products or services, and gaining new clients.[19]

EU efforts so far: laying the groundwork to make the most of AI

AI has featured in the EU research and development framework programmes since 2004 with a specific focus on robotics. Investments increased to up to EUR 700 million for 2014-2020, complemented by EUR 2.1 billion of private investments as part of a public-private partnership on robotics.[20] These efforts have significantly contributed to **Europe's leadership in robotics**.

Overall, around EUR 1.1 billion has been invested in AI-related research and innovation during the period 2014-2017 under the Horizon 2020 research and innovation programme, including in big data, health, rehabilitation, transport and space-oriented research.

***Projects funded by the EU have** developed for example:*

- *an unmanned agricultural vehicle that can mechanically remove weeds, reducing the need for pesticides;*
- *a highway pilot project using AI & Internet of Things to provide safe driving recommendations and reduce road fatalities;*
- *a robotic ortho-prosthesis to restore mobility to amputees;*
- *robots to take care of repetitive tasks for workers in car manufacturing plants and improve the efficiency of the manufacturing process.*

Additionally, the Commission has launched major initiatives which are key for AI. These include the development of more efficient electronic components and systems, such as **chips specifically built to run AI operations** (neuromorphic chips)[21]; **world-class high-performance computers**[22]**,** as well as flagship projects on **quantum technologies** and on the mapping of the **human brain**.[23]

3. THE WAY FORWARD: AN EU INITIATIVE ON AI

3.1. Boosting the EU's technological and industrial capacity and AI uptake across the economy

The public and private sectors must seize the opportunities that come both from developing innovative AI solutions and applying them to a range of fields.[24]

The EU should be **ahead of technological developments in AI** and ensure they are swiftly taken up across its economy. This implies **stepping up investments** to strengthen fundamental research and make scientific breakthroughs, upgrade AI research infrastructure,

[19] https://ec.europa.eu/growth/tools-databases/dem/monitor/scoreboard
[20] https://eu-robotics.net/sparc/.
[21] Neuromorphic chips are modelled on biological structures such as brains. This project is part of the Electronic Components and Systems for European Leadership joint undertaking (EUR 4.8 billion of public-private investments by 2020).
[22] https://ec.europa.eu/digital-single-market/en/eurohpc-joint-undertaking. This infrastructure will underpin the European Open Science Cloud that will offer researchers a virtual environment to store, process, share and re-use their data across disciplines and borders: https://ec.europa.eu/research/openscience/
[23] https://ec.europa.eu/digital-single-market/en/fet-flagships
[24] The recent report of the "High Level Group on Industrial Technologies" recognised AI as a "key enabling technology" highlighting the transformative role of AI and the necessity for the industry to use AI to maintain its leadership: http://ec.europa.eu/research/industrial_technologies/pdf/re_finding_industry_022018.pdf

develop AI applications in key sectors from health to transport, facilitate the uptake of AI and the access to data.

Joint effort by both the public (national and EU levels) **and private sectors** are needed to gradually increase overall investments by 2020 and beyond, in line with the EU's economic weight and investments on other continents.

Public and private **research and development investments in AI** in the EU last year were estimated to total EUR 4-5 billion.[25] **The EU as a whole (public and private sectors combined)** should aim to increase this investment to **at least EUR 20 billion by the end of 2020**. It should then **aim for more than EUR 20 billion per year over the following decade** (this objective does not pre-empt any decision to be taken with respect to the next EU multiannual financial framework).

The Commission will work with Member States on a coordinated plan to help align and step up investments, building on the declaration of cooperation signed on 10 April 2018.

Without such efforts, the EU risks losing out on the opportunities offered by AI, facing a brain-drain and being a consumer of solutions developed elsewhere. The EU should therefore strengthen its status as a research powerhouse while bringing more innovation to the market. A vast majority of European companies – whether large or small – should also adopt AI technologies.

Stepping up investments

2018-2020

To support joint efforts, **the Commission is increasing investments in AI** under the research and innovation framework programme Horizon 2020 to around **EUR 1.5 billion by the end of 2020** (this works out as an average of EUR 500 million per year and represents an increase of around 70%). Under the existing public-private partnerships (for example in robotics and big data), this investment will trigger an additional **EUR 2.5 billion** over the same period.

These investments will aim at consolidating research and innovation in AI, encouraging testing and experimentation, strengthening AI excellence research centres and starting efforts to bring AI to all potential users, with a focus on small and medium-sized enterprises.

If Member States[26] **and the private sector** (beyond established partnerships) **make similar investment efforts, the total investments in the EU** will grow to around EUR 7 billion per year, totalling **more than EUR 20 billion by the end of 2020**. This will position the EU well to further increase efforts over the next decade.

[25] Estimate based on data on public and business spending in research and development (R&D) in information and communication technologies (ICT) (source: Prospective Insights in ICT R&D, PREDICT, European Commission) and the share of funding in AI as part of the Commission's research and development budget in information and communication technologies since 2014 (around 13%). Building on previous trends, a similar share is calculated for government budget allocations for research and development and business expenditure on research and development which represents the major part of investments (ca. EUR 4 billion, which is consistent with recent findings by McKinsey).

[26] For example, France has just announced a EUR 1.5 billion investment in AI over five years.

Strengthening research and innovation from the lab to the market

The Commission will support **AI technologies both in basic and industrial research**[27]. This includes investments in projects in key application areas such as health, connected and automated driving, agriculture, manufacturing, energy, next generation internet technologies, security and public administrations (including justice). Funding will also reinforce European strengths in embodied AI/robotics.

The Commission will also **support breakthrough market-creating innovation such as AI** through the pilot of the **European Innovation Council**.[28] A budget of EUR 2.7 billion is made available for 2018-2020 to support 1,000 potential breakthrough projects and 3,000 feasibility awards. This pilot scheme can be particularly helpful for AI development as AI technology is expected to be part of many projects, for applications in e.g. health, agriculture and manufacturing.

Funding in fundamental research is expected to be provided by the **European Research Council**, based on scientific excellence. **Marie Skłodowska-Curie actions** provide grants for all stages of researchers' careers and have supported research in AI in the past years.

Supporting AI research excellence centres across Europe

Building on Member States' efforts to **jointly establish AI-focused research centres**, the Commission will support and strengthen AI excellence centres across Europe. The Commission will also encourage and facilitate their collaboration and networking.

Bringing AI to all small businesses and potential users

Europe can only reap the full benefits of AI if it is available and accessible to all. The Commission will **facilitate access of all potential users, especially small and medium-sized enterprises, companies from non-tech sectors and public administrations, to the latest technologies and encourage them to test AI**. To this end, the Commission will support the development of an "AI-on-demand platform". This will provide a single access point for all users to relevant AI resources in the EU, including knowledge, data repositories, computing power (cloud, high performance computing), tools and algorithms. It will offer services and provide support to potential users of the technology, analyse the business case behind AI in their specific circumstances and help them to integrate AI solutions in their processes, products and services.

To facilitate access to the platform, the existing network of more than 400 Digital Innovation Hubs[29]

Digital Innovation Hubs *help companies (especially small and medium-sized enterprises) to take advantage of digital opportunities. They offer expertise on technologies, testing, skills, business models, finance, market intelligence and networking.*

For example, a small company that produces metal parts for the automotive industry could consult the regional hub (which can be a science park for example) and ask for advice on how to improve the manufacturing process with AI. Experts from the hub would then visit the factory, analyse the production process, consult with other AI experts in the network of hubs, make a proposal and then implement it. These activities would be partially financed with EU money.

[27] The guiding principle of all support for AI-related research will be the development of "responsible AI", putting the human at the centre, see the Commission's "Responsible Research and Innovation" workstream: https://ec.europa.eu/programmes/horizon2020/en/h2020-section/responsible-research-innovation

[28] https://ec.europa.eu/programmes/horizon2020/en/h2020-section/european-innovation-council-eic-pilot

[29] See also the Commission's Communication of 19 April 2016 on Digitising European Industry (COM/2016/0180 final) and list of hubs.

will be instrumental. Further Hubs are coming on stream and a dedicated network of **Digital Innovation Hubs focused on AI** will be created.

The Commission will also analyse systemic shifts in value chains in order to anticipate AI opportunities for small and medium-sized enterprises, pilot critical industrial AI applications in non-tech sectors, and reinforce the European advanced manufacturing support centre for small and medium-sized enterprises.

Supporting testing and experimentation

Testing of and experimenting with AI products and services is crucial to make them market-ready, ensure compliance with safety standards and rules as well as security by design and enable policymakers to gain experience with new technologies to devise suitable legal frameworks. The Commission will support the set-up of testing and experimentation infrastructures that are open to businesses of all sizes and from all regions. Building on the established network of Digital Innovation Hubs, a **first series of testing and experimentation infrastructures for AI** products and services will be set up in the areas of healthcare, transport, infrastructure inspection and maintenance, agrifood and agile production.

Attracting private investments

On top of investments under the research and innovation framework programme, a sufficient level of private investments in the AI transformation is crucial. The **European Fund for Strategic Investments** will be further mobilised to attract private investment to support the development and the uptake of AI, as part of the wider efforts to promote digitisation. The Commission will work with the European Investment Bank Group with the aim of reaching **at least EUR 500 million in total investments** in that area in the period 2018-2020. In addition, the European Commission and the European Investment Fund have just launched a EUR 2.1 billion Pan-European Venture Capital Funds-of-Funds programme – **VentureEU** – to boost investment in innovative startup and scale-up companies across Europe. The Commission also provides support as part of its **initiatives to digitise industry**[30].

In 2018-20[31], the Commission will invest around **EUR 1.5 billion** in:

- **research and innovation in AI technologies** to strengthen European industrial leadership, excellence in science, and support AI applications which address societal challenges in sectors such as health, transport and agrifood. The Commission will also support breakthrough, market-creating innovation through the pilot phase of the European Innovation Council;
- strengthening **AI research excellence centres**; and
- the **uptake of AI across Europe**, via a **toolbox for potential users, with a focus on small and medium-sized enterprises, non-tech companies and public administrations**:

[30] The Commission has just launched the Strategic Forum for Important Projects of Common European Interest to identify and ensure appropriate large-scale finance for value chains of strategic importance for Europe including the integration of AI to strengthen EU industrial leadership. Moreover, the Commission supports and facilitates inter-regional partnerships for investments in advanced technologies and AI through its Smart Specialisation Platform on Industrial Modernisation.

[31] Actions will stem from the work programme Horizon 2020. They will be financed within the current financial programming envelope and subject to future revision of the work programme in the frame of the comitology procedure.

this will include an **AI-on-demand platform** giving support and easy access to the latest algorithms and expertise; a **network of AI-focused Digital Innovation Hubs** facilitating **testing and experimentation**; and the set-up of **industrial data platforms** offering high quality datasets.

In addition, the Commission aims to stimulate more private investments in AI under the **European Fund for Strategic Investments** (**at least EUR 500 million** in 2018-20).

Beyond 2020

Commission proposals under the **next EU multiannual financial framework (2021-2027)** will open the door to investments into:

- **upgrading** the pan-European **network of AI excellence centres**;
- **research and innovation in fields such as explainable AI**[32]**, unsupervised machine learning, energy and data efficiency**[33];
- additional Digital Innovation Hubs, world-leading **testing and experimentation facilities** in areas such as transport, healthcare, agrifood and manufacturing, supported by **regulatory sandboxes**[34];
- supporting the adoption of AI by organisations across all sectors, including **public interest applications**, through co-investment with Member States;
- exploring joint **innovation procurement** for the use and development of AI; and
- a **support centre for data sharing**, which will be closely linked with **the AI-on-demand** platform to facilitate development of business and public sector applications.

The Commission also intends to continue its support for technologies and infrastructure that underpin and enable AI such as high-performance computing, microelectronics, photonics, quantum technologies, the Internet of Things and cloud.

In doing so, the Commission will support more **energy-efficient technologies** and infrastructure, **making the AI value chain greener**.

[32] In order to increase transparency and minimise the risk of bias or error, AI systems should be developed in a manner which allows humans to understand (the basis of) their actions.
[33] These being methods to use less data in order to train AIs.
[34] These are testing grounds for new business models that are not (yet) regulated.

Making more data available

AI needs vast amounts of data to be developed. Machine learning, a type of AI, works by identifying patterns in available data and then applying the knowledge to new data.[35] The larger a data set, the better even subtle relations in the data can be discovered. When it comes to using AI, data-rich environments also provide for more opportunities. This is because data is the way the algorithm learns about and interacts with its environment. For example, if all machines and processes in a factory continuously produce data, it is likely that further automation and optimisation can be achieved with the help of AI. In an analog setting, e.g. in a paper-based operation without digitised data about what is happening, that is not the case.

In view of this, access to data is a key ingredient for a competitive AI landscape, which the EU should facilitate.

The EU has made significant efforts over the past 15 years **to open up public sector information and publicly funded research results** for re-use, such as data generated by the EU's space programmes (Copernicus[36], Galileo). With its initiative to improve the accessibility and re-usability of such data, this body of data will grow further.

Public policy should also encourage **the wider availability of privately-held data**, while ensuring full respect for legislation on the protection of personal data. The Commission calls on companies to recognise the importance of non-personal data re-use, including for AI training purposes.

A new **support centre for data sharing** will provide public authorities and companies with legal and technical support when trying to access data from public sector bodies and companies.

Deep learning *has been a game-changer for AI with a tremendous improvement in performance for specific tasks such as image or speech recognition, or machine translation.*

Training a deep learning algorithm to classify objects works by exposing it to a large number of labelled examples (e.g. pictures) that are correctly categorised (e.g. pictures of planes).

Once trained, algorithms can correctly classify objects that they have never seen, in some cases with accuracies that exceed those of humans.

Significant advances in these technologies have been made through the use of large data sets and unprecedented computing power.

The Commission will continue to study how more data can be made available.

Alongside this Communication, the Commission has put forward a set of initiatives to grow the European data space[37]. These are:

- an **updated Directive on public sector information**, e.g. traffic, meteorological, economic and financial data or business registers;
- **guidance on sharing private sector data in the economy** (including industrial data);
- an **updated Recommendation on access to and preservation of scientific information**; and

[35] Sometimes finding the pattern is itself the goal of the activity: in text and data mining, researchers use algorithms to "read" a large numbers of texts (e.g. scientific papers on chemistry) and automatically extract knowledge (e.g. finding facts that are not explicitly stated in any one of the papers but can be derived from the whole corpus). The Commission introduced an exception for text and data mining as part of the modernisation of EU copyright rules.

[36] Copernicus Data and Information Access Services: http://copernicus.eu/news/upcoming-copernicus-data-and-information-access-services-dias

[37] https://ec.europa.eu/digital-single-market/en/policies/building-european-data-economy

- a **Communication on the digital transformation of health and care**, including sharing of genomic and other health data sets.

3.2. Preparing for socioeconomic changes

Throughout history, the emergence of new technologies – from electricity to the internet – has changed the nature of work. It has brought major benefits to our society and economy, but also raised concerns. The emergence of automation, robotics and AI is transforming the labour market, and it is essential for the EU to manage this shift.

These technologies can make the life of workers easier. They can, for example, help them with repetitive, strenuous and even dangerous tasks (for example cleaning unsafe or difficult to access locations such as industrial pipes). They can also help summarise large amounts of data, provide more accurate information and suggest decisions, including using AI to assist doctors with diagnosis. They ultimately help to **enhance people's abilities**. Against the background of an ageing society, AI can provide new solutions to support more people to participate and remain in the labour market, including persons with disabilities. **New jobs and tasks will emerge as a result of AI**, some of which are difficult, or even impossible to predict. Other jobs and tasks will be replaced. While the exact quantification of AI's impact on jobs is difficult to determine at this stage, the need for action is clear.

Overall there are three main challenges for the EU – highlighting the fundamental role of education and training, including of teachers and trainers themselves, for which responsibility lies with Member States. The first challenge is to **prepare the society as a whole**. This means helping all Europeans to develop basic digital skills, as well as skills which are complementary to and cannot be replaced by any machine such as critical thinking, creativity or management. Secondly, the EU needs to focus efforts to help workers in **jobs which are likely to be the most transformed or to disappear** due to automation, robotics and AI. This is also about ensuring access for all citizens, including workers and the self-employed[38], to social protection[39], in line with the **European Pillar of Social Rights**. Finally, the EU needs to **train more specialists in AI**, building on its long tradition of academic excellence, create the right environment for them to work in the EU and attract more talent from abroad.

Leaving no one behind

In 2016, the European Commission launched a comprehensive plan to help equip people with the right skills for the evolving labour market: a **New Skills Agenda for Europe**[40]. As part of this agenda, the Commission issued a Recommendation for Member States on "Upskilling Pathways: New Opportunities for Adults" to improve their basic literacy, numeracy and digital skills. A Recommendation was also adopted on key competences for lifelong learning, focusing notably on the acquisition of competences in sciences, technology, engineering and mathematics (STEM), digital competences, entrepreneurship and creativity. The Commission also presented a Digital Education Action Plan[41] which aims to foster digital skills and

38 http://ec.europa.eu/social/BlobServlet?docId=19158&langId=en

39 Automation may impact the way social protection is financed, necessitating a proper reflection on the sustainability and adequacy of social security systems.

40 http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52016DC0381

41 https://ec.europa.eu/education/sites/education/files/digital-education-action-plan.pdf

competences for all citizens. This plan explores the impact of AI in education and training through pilots.

While digitisation is affecting the structure of the labour market in particular through the automation of middle-skilled jobs, AI could have a more significant impact on lower skilled jobs.[42] If not addressed early and proactively, this may exacerbate inequalities between people, regions and industries in the EU.

To manage the AI transformation, workers whose jobs are changing or may disappear due to automation must have every opportunity to acquire the skills and knowledge they need, to master new technology and be supported during labour market transitions. This anticipatory approach and focus on investing in people is a cornerstone of a human-centric, inclusive approach to AI, and will require a significant investment. National schemes will be essential for providing such up-skilling and training. They will benefit from support by the European Structural and Investment Funds (supporting skills development with EUR 27 billion over the period 2014-2020, out of which the European Social Fund invests 2.3 billion specifically in digital skills) and should also benefit from support from the private sector. The Commission will also continue to support research into human-AI interaction and cooperation.

Nurturing talent, diversity and interdisciplinarity

AI has brought about new job profiles, including in the area of developing machine-learning algorithms and other digital innovations.[43] Overall, the number of specialists in information and communication technologies in the EU has grown annually by 5% since 2011, creating 1.8 million jobs and rapidly increasing its share of total employment from 3% to 3.7% in just five years. There are at least 350,000 vacancies for such professionals in Europe, pointing to significant skills gaps.[44] This is why Europe should strive to **increase the number of people trained in AI** and **encourage diversity**. More women and people of diverse backgrounds, including people with disabilities, need to be involved in the development of AI, starting from inclusive AI education and training, in order to ensure that AI is non-discriminatory and inclusive. **Interdisciplinarity** should also be supported (by encouraging joint degrees, for example in law or psychology and AI). The importance of ethics in the development and use of new technologies should also be featured in programmes and courses. And it is not only about training the best talent, but also creating an **attractive environment for them to stay in the EU**.

Initiatives to encourage more young people to choose AI subjects and related fields as a career should be promoted. The Commission has recently launched the "Digital Opportunity Traineeships"[45], supporting internships aimed at acquiring advanced digital skills, and a number of actions of the Digital Skills and Jobs Coalition[46] aim at spreading coding skills and increasing the number of experts in digital.

Ensuring that workers are given the chance to adapt and to have access to new opportunities will be crucial for people to accept AI. Like any other technology, AI is not just imposed on society. It is up to governments, in dialogue with the social partners and civil society bodies,

[42] Organisation for Economic Co-operation and Development, "Automation, skills use and training", 2018.
[43] https://www.cognizant.com/whitepapers/21-jobs-of-the-future-a-guide-to-getting-and-staying-employed-over-the-next-10-years-codex3049.pdf
[44] http://www.pocbigdata.eu/monitorICTonlinevacancies/general_info/
[45] https://ec.europa.eu/digital-single-market/en/digital-opportunity-traineeships-boosting-digital-skills-job
[46] https://ec.europa.eu/digital-single-market/en/digital-skills-jobs-coalition

to collectively steer the process to ensure that its benefits are widely shared, that all citizens are suitably equipped to take full advantage of this technology and that a broader reflection on potentially deeper societal changes is taking place.

In 2018, in order to support the efforts of Member States which are responsible for labour and education policies, the Commission will:

- set up **dedicated (re-)training schemes** in connection with the Blueprint on sectoral cooperation on skills[47] – which brings together businesses, trade unions, higher education institutions and public authorities – for professional profiles which are at risk of being automated, with financial support from the European Social Fund[48];
- gather detailed analysis and expert inputs to **anticipate the changes on the labour market and the skills mismatch** across the EU, and inform decision-making at EU, national and local levels. More specifically, the Commission will (i) publish a foresight report on the impact of AI in education; (ii) launch pilots to predict the training requirements for future competence profiles; and (iii) publish an expert **report addressing the labour market impacts of AI**, with **recommendations**;
- support Digital Opportunity **Traineeships** (2018-20) **in advanced digital skills** for students and fresh graduates;
- encourage, through the Digital Skills and Jobs Coalition, **business-education partnerships** to take steps to attract and retain more AI talent and to foster continued collaboration; and
- invite **social partners** to include AI and its impact on the economy and employment, including the importance of diversity and gender balance in AI jobs, in their joint work programmes at sectoral and cross-sectoral level where relevant.

The **European Institute of Innovation and Technology** will integrate **AI across curricula in the education courses it supports**, in order to contribute to developing a talent pool for AI in Europe.

Proposals under the next EU multiannual financial framework (2021-2027) will include strengthened support for the acquisition of advanced digital skills including AI-specific expertise.

The Commission also intends to broaden the scope of the current European Globalisation Adjustment Fund beyond redundancies caused by delocalisation, including to those resulting from digitisation and automation.

3.3. Ensuring an appropriate ethical and legal framework

An environment of trust and accountability around the development and use of AI is needed.

The **values** set out in Article 2 of the Treaty on European Union constitute the foundation of the rights enjoyed by those living in the Union. In addition, the **EU Charter of Fundamental**

[47] http://ec.europa.eu/social/main.jsp?catId=1415&langId=en

[48] The cooperation now focuses on the automotive, maritime technology, space, textile and tourism sectors, and will address six other sectors in the future: additive manufacturing; construction; green technologies and renewable energy; maritime shipping; paper-based value chain; steel industry.

Rights brings together all the personal, civic, political, economic and social rights enjoyed by people within the EU in a single text.

The EU has a strong and balanced regulatory framework to build on, which can set the global standard for a sustainable approach to this technology. The Union has **high standards in terms of safety and product liability**. The first EU-wide rules on **network and information systems security** and stronger rules on the **protection of personal data** will become a reality in May 2018.

The **General Data Protection Regulation** ensures a high standard of personal data protection, including the principles of data protection by design and by default. It guarantees the free flow of personal data within the Union. It contains provisions on decision-making based solely on automated processing, including profiling. In such cases, data subjects have the **right to be provided with meaningful information** about the logic involved in the decision.[49] The General Data Protection Regulation also gives individuals the right not to be subject solely to automated decision-making, except in certain situations.[50] The Commission will closely follow the Regulation's application in the context of AI and calls on the national data protection authorities and the European Data Protection Board to do the same.

The Commission has also put forward a series of proposals under the **Digital Single Market** strategy that will be a key enabler for the development of AI, such as the Regulation on the free flow of non-personal data, and that will strengthen trust in the online world, such as the ePrivacy Regulation and the Cybersecurity Act. These proposals need to be adopted as soon as possible. This is essential as **citizens and businesses alike need to be able to trust the technology they interact with**, have a predictable legal environment and rely on effective safeguards protecting fundamental rights and freedoms.

To further strengthen trust, people also need to understand how the technology works, hence the importance of research into the **explainability of AI systems**. Indeed, in order to increase transparency and minimise the risk of bias or error, AI systems should be developed in a manner which allows humans to understand (the basis of) their actions.

Like every technology or tool, AI can be used to positive but also to malicious ends. Whilst AI clearly generates new opportunities, it also poses challenges and risks, for example in the areas of safety and liability, security (criminal use or attacks), bias[51] and discrimination.

Reflection will be needed on interactions between AI and intellectual property rights, from the perspective of both intellectual property offices and users, with a view to fostering innovation and legal certainty in a balanced way.[52]

Draft AI ethics guidelines

As a first step to address ethical concerns, **draft AI ethics guidelines will be developed by the end of the year**, with due regard to the Charter of Fundamental Rights of the European Union. The Commission will bring together all relevant stakeholders in order to help develop these draft guidelines.

[49] Articles 13 (2) f), 14 (2) g) and 15 (1) h) of the General Data Protection Regulation.
[50] Article 22 of the General Data Protection Regulation.
[51] Depending on the data input that is used to train AI systems, their outputs can be biased.
[52] Using AI to create works can have implications on intellectual property, with questions arising for instance on patentability, copyright and right ownership.

The draft guidelines will address issues such as the future of work, fairness, safety, security, social inclusion and algorithmic transparency. More broadly, they will look at the impact on fundamental rights, including privacy, dignity, consumer protection and non-discrimination. They will build on the work of the European Group on Ethics in Science and New Technologies[53] and take inspiration from other similar efforts.[54] Companies, academic institutions, and other organisations from civil society bodies will be invited to contribute. In parallel, the Commission will continue its work towards progress on ethics at international level[55].

While self-regulation can provide a first set of benchmarks against which emerging applications and outcomes can be assessed, public authorities must ensure that the regulatory frameworks for developing and using of AI technologies are in line with these values and fundamental rights. The Commission will monitor developments and, if necessary, review existing legal frameworks to better adapt them to specific challenges, in particular to ensure the respect of the Union's basic values and fundamental rights.

Safety and liability

The emergence of AI, in particular the complex enabling ecosystem and the feature of autonomous decision-making, requires a reflection about the suitability of some established rules on safety and civil law questions on liability.

For instance, advanced robots and Internet of Things products empowered by AI may act in ways that were not envisaged at the time when the system was first put into operation. Given AI's widespread uses, both horizontal and sectoral rules may need to be reviewed[56].

The EU safety framework[57] already addresses the intended use and foreseeable (mis)use of products when placed on the market. This has led to the development of a solid body of standards in the area of AI-enabled devices that is continuously being adapted in line with technological progress..

The further development and promotion of such safety standards and support in EU and international standardisation organisations will help enable European businesses to benefit from a competitive advantage, and increase consumer trust[58].

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[53] The European Group on Ethics in Science and New Technologies is an advisory group of the Commission.

[54] At the EU level, the EU Fundamental Rights Agency will carry out an assessment of the current challenges faced by producers and users of new technology with respect of fundamental rights compliance. The European Group on Ethics in Science and New Technologies also published a relevant statement on AI, Robotics and 'Autonomous' Systems on 9 March 2018. Examples of international efforts: Asilomar AI principles (https://futureoflife.org/ai-principles/), Montréal Declaration for Responsible AI draft principles (https://www.montrealdeclaration-responsibleai.com/), UNI Global Union Top 10 Principles for Ethical AI (http://www.thefutureworldofwork.org/opinions/10-principles-for-ethical-ai/).

[55] The European Commission's International Dialogue on Bioethics and Ethics in Science and New Technologies brings together the National Ethics Councils of EU Member States and of third countries, to work together on those matters of common concern.

[56] For any new regulatory proposals that shall be needed to address emerging issues resulting from AI and related technologies, the Commission applies the Innovation Principle, a set of tools and guidelines that was developed to ensure that all Commission initiatives are innovation friendly: https://ec.europa.eu/epsc/publications/strategic-notes/towards-innovation-principle-endorsed-better-regulation_en

[57] For example, the Machinery Directive, the Radio Equipment Directive, the General Product Safety Directive as well as specific safety rules for example for medical devices or toys.

[58] Standards should also cover interoperability, which is crucial for offering consumers greater choices and ensuring fair competition.

The Commission is currently assessing whether the safety and national and EU liability frameworks are fit for purpose in light of these new challenges or whether any gaps should be addressed. A high level of safety and an efficient redress mechanism for victims in case of damages helps to build user trust and social acceptance of these technologies.

Evaluations of the Product Liability Directive[59] and the Machinery Directive have already been conducted.[60] An initial assessment was also carried out on the current liability frameworks in light of AI and emerging technologies.[61] An expert group will help the Commission to analyse these challenges further.[62]

Empowering individuals and consumers to make the most of AI

The large-scale use of AI-enabled tools in business-to-consumer transactions needs to be fair, transparent and compliant with consumer legislation. Consumers should receive clear information on the use, features and properties of AI-enabled products. Individuals should be able to control the data generated by using these tools and should know whether they are communicating with a machine or another human. In particular, when interacting with an automated system, consideration should be given to when users should be informed on how to reach a human and how to ensure that a system's decisions can be checked or corrected.

The Commission will:

- set a framework for stakeholders and experts – the European AI Alliance – to develop **draft AI ethics guidelines**, with due regard to fundamental rights, **by the end of the year**, in cooperation with the European Group on Ethics in Science and New Technologies;
- **issue a guidance document on the interpretation of the Product Liability Directive** in light of technological developments **by mid-2019**. This will seek to ensure legal clarity for consumers and producers in case of defective products;
- publish, **by mid-2019**, a **report on** the broader **implications** for, potential **gaps in and orientations for,** the **liability** and **safety frameworks** for AI, Internet of Things and robotics;
- support research in the development of **explainable AI** and implement a pilot project proposed by the European Parliament on **Algorithmic Awareness Building**[63], to gather a solid evidence-base and support the design of policy responses to the challenges brought by automated decision-making, including biases and discrimination (2018-2019); and
- support national and EU-level **consumer organisations and data protection supervising authorities** in building an understanding of AI-powered applications with the input of the European Consumer Consultative Group and of the European Data Protection Board.

[59] The Product Liability Directive states that if a defective product causes any damage to consumers or their property, the producer has to provide compensation irrespectively of whether there is negligence or fault on their part.

[60] The evaluation of the Machinery Directive indicates that some provisions do not explicitly address certain aspects of emerging digital technologies, and the Commission will examine whether this requires legislative changes. On the evaluation of the Product Liability Directive, the Commission will issue an interpretative guidance document, clarifying important concepts in the Directive.

[61] See the Staff Working Document on Liability accompanying this Communication (SWD (2018)137).

[62] http://ec.europa.eu/newsroom/just/item-detail.cfm?item_id=615947

[63] https://ec.europa.eu/digital-single-market/en/algorithmic-awareness-building

3.4. Joining forces

Engaging Member States

Several Member States have developed or are working towards strategies to support AI. On 29 March 2018, France presented its national strategy for AI, building on the Villani report.[64] Germany, following the example of "Industrie 4.0", has set up a platform on learning systems to enable a strategic dialogue between academia, industry and the government, and it has put forward a report on the ethics of automated and connected driving.[65] Finland has put forward its 'Tekoälyaika' strategy to make it a leader in the field.[66] Every Member State is encouraged to have an AI strategy, including on investment.

Sharing best practices, identifying synergies and aligning action where relevant will maximise the impact of investments in AI and help the EU as a whole to compete globally. Cooperating on interoperability and data sets, and working together on legal solutions will prevent a fragmentation of the single market and therefore fuel the emergence of AI startups. 24 Member States and Norway have already committed to joining forces on AI and entering into a strategic dialogue with the Commission.[67] **The Commission will facilitate this dialogue and aim to agree a coordinated plan on AI with Member States by the end of the year.**

Engaging stakeholders: setting up a European AI Alliance

Given the scale of the challenge associated with AI, the full mobilisation of a diverse set of participants, including businesses, consumer organisations, trade unions, and other representatives of civil society bodies is essential. The Commission will therefore facilitate the creation and operation of **a broad multi-stakeholder platform,** the **European AI Alliance**, to work on all aspects of AI.[68] The Commission will also facilitate interactions of the Alliance with the European Parliament, Member States, the European Economic and Social Committee, the Committee of the Regions as well as international organisations. The Alliance will be a space for sharing best practices, encourage private investments and activities related to the development of AI.

[64] https://www.aiforhumanity.fr
[65] https://www.plattform-lernende-systeme.de
[66] https://tekoalyaika.fi/
[67] https://ec.europa.eu/digital-single-market/en/news/eu-member-states-sign-cooperate-artificial-intelligence
[68] https://ec.europa.eu/digital-single-market/en/news/call-high-level-expert-group-artificial-intelligence

Monitoring AI development and uptake

Many of today's debates about AI are based on opinions, hearsay and assumptions – not always on facts and science. To ensure quality input and to inform policy-making, the Commission will monitor the uptake of AI applications across the economy and identify potential shifts in industrial value chains caused by AI as well as societal and legal developments and the situation on the labour market. It will also benchmark the technical capabilities of AI components and systems to give a realistic understanding of where the technology stands, and help increase public awareness.[69] The Commission will also regularly assess progress towards the objectives and the initiatives set out in this Communication.

International outreach

International discussions on AI have intensified after Japan's G7 Presidency put the topic on the table in 2016. The EU has supported these discussions both in G7 ministerial meetings and at the Organisation for Economic Co-operation and Development, which is becoming a major international venue to discuss this topic. More specifically, the Commission has encouraged the discussions on AI ethics within the G7.

With AI being easily tradeable across borders, only global solutions will be sustainable in this domain. The G7/G20, United Nations and Organisation for Economic Co-operation and Development have begun to address the role of AI, including in the military domain. The EU will continue to encourage discussions on AI and its various dimensions – including research and innovation cooperation as well as competitiveness – in such fora. It will promote the use of AI, and technologies in general, to help solve global challenges, support the implementation of the Paris Climate agreement and achieve the United Nations Sustainable Development Goals.

The EU can make a unique contribution to the worldwide debate on AI based on its values and fundamental rights.

- **By the end of the year**, the Commission will work, as part of the existing European platform of national initiatives to digitise industry, on a **coordinated plan with Member States** in order to maximise the impact of investments at EU and national levels, exchange on the best way for governments to prepare Europeans for the AI transformation and address legal and ethical considerations. In parallel, the Commission will **systematically monitor AI-related developments**, e.g. policy initiatives in the Member States, AI uptake and its impact on labour markets as well as AI capabilities, including high-level benchmarking, showcasing current capabilities and developing an AI index in order to inform the discussions.
- **By July 2018**, the **European AI Alliance** will be set up. It will involve all relevant stakeholders to gather input, exchange views, develop and implement common measures to encourage the development and use of AI.

4. CONCLUSION

The EU has a strong scientific and industrial base to build on, with leading research labs and universities, recognised leadership in robotics as well as innovative startups. It has a

[69] This work shall also be informed by the EU Agency on Fundamental Rights.

comprehensive legal framework which protects consumers while promoting innovation and it is making progress in creating a Digital Single Market. **The main ingredients are there for the EU to become a leader in the AI revolution**, in its own way and based on its values.

The approach to AI described in this document shows the way forward and highlights the need to join forces at European level, to ensure that all Europeans are part of the digital transformation, that adequate resources are devoted to AI and that the Union's values and fundamental rights are at the forefront of the AI landscape.

Together, we can place the **power of AI at the service of human progress**.