Career options and necessary technical skills in AI

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ABSTRACT. This chapter will present issues related to the labour market in Artificial Intelligence (AI) technologies, career opportunities in the industry, as well as AI technical skills. It is a fact that AI applications are growing globally, however the utilization of such technological competences require high specialization. The demand for skilled staff is usually covered by the global market because at national level this is not always possible, while at the same time jobs in AI technologies are estimated to skyrocket over the next decades. Today, at global level, demand is much higher than job offer, which appears to get worse in the coming years. Companies, such as Google, Amazon, Baidu, Microsoft etc. are investing billions in AI, and the AI-related job market is growing extremely rapidly. Moreover, a large number of ready AI tools, mainly in the Machine Learning (ML) field that has dominated the last decades of 21st century, offer opportunities to businesses and organizations to get involved and built machine learning solutions for their needs and customers. All of these job opportunities require specific knowledge and expertise or in other words specific technical skills, as they are referred to in this document.

1. INTRODUCTION

After three technological revolutions which have their origins in computers, smartphones and the internet, Artificial Intelligence (AI) is considered as the biggest technological shift that we have ever seen, according to Edouard d'Archimbaud, Head of Data & AI Lab, BNP Paribas (cited in the Capgemini report, 2017). The AI can be used to automate a process or system so that it can make smart decisions without uncertainty or even with uncertainty.

The modern field of AI was founded as an academic discipline in 1956, on the occasion of a summer conference at Dartmouth College, sponsored by the Defense Advanced Research Projects Agency (DARPA). Currently, AI is one of the most popular areas in computer science and engineering, but interest in the field hasn't been steady though the years, with periods of increased funding and progress (AI summer) alternating with stagnant periods of reduced interest (AI winter). Nowadays, as the reputation is increasing around AI, vendors have been scrambling to promote how their products and services use AI. Often what they refer to as AI is simply one component of AI, such as machine learning (ML).

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Artificial Intelligence is not just one technology. Many definitions are given, highlighting the many technologies, classified as AI. As Burn et al. (2021) claim "*Artificial intelligence is the simulation of human intelligence processes by machines, especially computer systems*". In that vein, specific applications of AI include expert systems, natural language processing, speech recognition and machine vision. Another definition of AI as it is expressed by Capgemini Consulting (2017) says that AI encompasses a range of technologies that learn over time as they are exposed to more data. In this frame, AI includes speech recognition, natural language processing, semantic technology, biometrics, machine and deep learning, swarm intelligence, and chatbots or voice bots. Applications of AI can be found in many sectors like healthcare, business, education, finance, law, manufacturing, banking, transportation, security, etc.

However, we would like to stress that because hardware, software and staffing costs for AI can be expensive, many vendors are including AI components in their standard offerings or providing access to artificial intelligence as a service (AIaaS) platform. AIaaS allows individuals and companies to experiment with AI for various business purposes and sample multiple platforms before making a commitment. These AI vendors are leading the market[1] by providing AI and ML through their popular cloud platforms, enabling companies to incorporate AI into applications and systems without the expense of in-house development. Popular AI cloud offerings include the following:

- **Amazon web services – AWS** (see https://aws.amazon.com/machine-learning/ai-services/). The clear leader in cloud computing, AWS offers both consumer and business-oriented AI products and services, and many of its professional AI services build on the AI services available in consumer products. Amazon Echo brings artificial intelligence into the home through the intelligent voice server, Alexa. For AWS, the company's primary AI services include Lex, a business version of Alexa; Polly, which turns text to speech; and Rekognition, an image recognition service.
- **IBM Watson Assistant** (see https://www.ibm.com/cloud/watson-assistant). Its efforts in recent years center around IBM Watson, an AI-based cognitive service, AI software as a service, and scale-out systems designed for delivering cloud-based analytics and AI services. It has been acquisitive, purchasing several AI startups over several years. It benefits from having a strong cloud platform.
- **Microsoft Azure Cognitive Services** (see https://azure.microsoft.com/en-us/services/cognitive-services/). Microsoft offers a mix of consumer-facing and business/IT AI projects. On the consumer side, it has Cortana, the digital assistant that comes with Windows and is now available for smartphones other than Windows Phone, and the chatbot Zo that talks like a teenager. On its Azure cloud service, Microsoft sells AI services such as bot services, machine learning, and cognitive services.

[1]For the top performing AI Companies of 2021, see James Maguire, April 9, 2021, Datamation.com, https://www.datamation.com/artificial-intelligence/ai-companies/

- **Google AI Cloud Platform** (see https://ai.google/). Google, a leader in AI and data analytics, is on a massive AI acquisition binge, having acquired a number of AI startups in the last several years. Google is deeply invested in furthering artificial intelligence capabilities. In addition to using AI to improve its services, Google Cloud sells several AI and machine learning services to businesses. It has an industry-leading software project in TensorFlow[2], as well as its own Tensor AI chip project.

Furthermore, it is worth mentioning that the adoption of AI differs dramatically among organizations. We can distinguish between three cases. The first case includes **giant tech companies** which are AI-leaders, having proceeded to investments of billions, like Google, Amazon, Microsoft, the Chinese multinational technology company Baidu, etc., and have developed a number of AI/ML tools and applications. The second case includes **high-tech performing companies**, which capture value from AI at the enterprise level. According to the McKinsey global survey (McKinsey & Company, 2020) on AI in 2395 participants, 1151 respondents (or 50%) said that their organizations have embedded AI into a process or product in at least one function or business unit. This type of companies can be considered as the ones that have already adopted AI in at least one business function. Finally, the last case is the majority of companies, **which have not discovered yet the benefits of AI and have not adopted any related technology**; they are still struggling to capitalize on the technology, although they are very likely to start in the near future. In addition, taking into account that the most high-performing companies have increased their investment in AI amid the COVID-19 crisis, although the changes vary by industry, the job positions in AI follow more or less the aforementioned three-tier scheme of AI adoption.

However, it is worth mentioning the difficulty for companies, other than giant/big tech companies, to design and ultimately adopt AI-based solutions. Most AI/ML projects do not always lead to the creation of real value for companies, either because the projects have not been properly designed or the business stakeholders have not actually accepted the applications. According to the 2021 Capgemini analysis (Capgemini Consulting, 2021) of the 10 most likely mistakes in AI/ML applications made at operational level, mistakes described by Elder in 2005, are still current today (Elder, 2005). These include: lack of (appropriate/relevant) data, focus on training algorithms and not on clear cross-validation frameworks that fit for application purposes, rely on one technique and not on a variety of modelling algorithms, ask the wrong question in the sense that we need to tailor our model to our task and not our task to our model, etc.

In this regard, the 2nd section presents issues related to the labour market and new technologies. Namely, it presents the effects of AI on the labour market, indicative areas of application of AI

[2] TensorFlow is an end-to-end open source platform for machine learning. It has a comprehensive, flexible ecosystem of tools, libraries and community.

technologies, the impact of the COVID-19 pandemic on AI industry, AI job opportunities and salaries in the sector, and finally the technical skills required for a career at the AI/ML sector. The chapter closes with comments and conclusions.

2. LABOUR MARKET AND NEW TECHNOLOGIES

2.1 The effects of AI on the labour market

The relationship between automation and employment is complicated. While automation eliminates old jobs, it also creates new jobs through micro-economic and macro-economic effects. In this and the next subsection we will try to highlight the two aspects of employment in relation to the new AI technologies. That is, on the one hand the drastic drop in employment, but on the other hand the increase of employment at the same time.

Technology steps increasingly lead to the simplification of people's everyday life. An example of this is the replacement of human work by robots and automated systems. Machines already do things we thought only humans could do. At international level, there is concern about the effects of AI on the labour market. Subjective estimates of the risk vary widely. For example, an OECD report classifies only 9% of U.S. jobs as "high risk", while other authors/executives estimate higher percentages of US jobs are at "high risk", as it is referred in the work of Frey & Osborne (2017), who estimate that 47% of US jobs are at high risk due to potential automation. Their opinion is based on the observation that many jobs are routine and repetitive. Their model predicts that most workers in US in transportation and logistics occupations, together with the bulk of office and administrative support workers, and labour in production occupations, are at risk. Thus, they conclude that low-skill workers will reallocate to tasks that are non-susceptible to computerisation –i.e., tasks requiring creative and social intelligence.

In that vein, as technology transforms the world of work the public policy response should include helping today's young people to become winners. UK has formed a specialized advisory group of top British educators and CEOs who recommended changes to secondary education in the UK. They concluded that "*empathy and other interpersonal skills are as important as proficiency in English and mathematics in ensuring young people's employment prospects*". The group urged that these skills be taught to all secondary students "*but with the process of learning these starting much earlier in school life*". These competencies "*should be embedded throughout the curriculum*". That is, everyone will need these skills, especially if they are going to work in positions that are at less risk from automation in the future (e.g. personal care providers, first responders, social worker, dieticians, nurses, etc.) which require human creativity, personal skills and social intelligence.

In year 2015, the authors Martin Ford and Geoff Colvin in an interview hosted by The Guardian (https://www.theguardian.com/technology/2015/sep/06/will-robots-create-destroy-jobs) warn that jobs may be automated in the next couple of decades, and many of the new jobs may not be "*accessible to people with average capability, even with retraining*". Economists point out that in the past, technology has tended to increase rather than reduce total employment, but they acknowledge that "*we're in uncharted territory*" with AI. As they claim, most common occupations in the US are salesperson, cashier, food and beverage server, office clerk and driver. As they say, about 90% of the US workforce is employed in occupations that existed 100 years ago. Occupations such as website designers, social media marketers, mobile app developers, etc., constitute a very small fraction of total employment and in many cases they require highly specialised, technical skills.

The same opinion has been adopted recently by the computer scientist Dr Nikolaos Bourbakis, distinguished professor in Information Technology and AI, in his speech at the Technical University of Crete (27 August, 2021), in which he claimed that until the year 2050 some 800 million to 1 billion of jobs will be replaced by AI and machines. He further stated that AI and Robotic machines will replace human jobs in production lines and automation, in advertisement and secretariat jobs, etc., and he concluded that "*the replacing time of these jobs is the critical point*" along with our preparedness with adaptable solutions.

In the same more or less direction, Walker (2017), Vice President of Pega systems, presenting the results of a survey of 6000 humans in six different countries, says that 70% of the surveyed participants are fearful of AI and 25% believe it will take over the world and enslave humanity. While 31% also believe humans will be replaced by robots on the job, some contend that AI assistance on the job would help improve work/life balance, freeing them up to do more meaningful work and have more leisure time.

Conversely, there are opposing views regarding the effects of AI on employment. Namely, it is suggested that, for example, the manufacturing sector demonstrates that the effect of technology on employment is more complicated than a simple story of "*automation causes job losses*" in the affected industries. In this direction, Bessen (2018) states that everything is related to the elasticity of demand. According to the demand model that includes both income and price effects on demand, allowing both to have changing elasticities over time, he examines US data for three key industrial sectors (textile, steel and automotive industries). The demand accurately predicts the rise and fall of employment in these industries. This model provides a useful framework for exploring how AI is likely to affect jobs over the next 10 or 20 years. He believes that it is important whether a sector is partially or fully automated. Namely, in manufacturing, technology has sharply reduced jobs in recent decades. But before that, for over a century, employment grew, even in industries experiencing rapid technological change. Demand was highly elastic at

first and then became inelastic. The effect of AI on jobs will similarly depend critically on the nature of demand.

Bessen states that "*the pace of change of a new technology is not sufficient by itself to determine the impact of that technology on employment"*. To explain this issue, he asks the following question: "*to what extent will AI completely automate occupations and to what extent will it, instead, merely automate some, but not all, tasks performed by an occupation. If humans are completely replaced, demand no longer affects employment because there isn't any demand for humans. In the past, ...some occupations were eliminated for a variety of reasons. In many cases, demand for the occupational services declined (e.g., boardinghouse keepers); in some cases, demand declined because of technological obsolescence (e.g., telegraph operators). This, however, is not the same as automation. In only one case — elevator operators — can the decline and disappearance of an occupation be largely attributed to automation. Nevertheless, this 60-year period witnessed extensive automation; it was just mostly partial automation*".

He goes on emphatically about total automation compared to partial automation and its effect on employment by stating that "*this same pattern is likely to be true for AI over the next 10 or 20 years for the simple reason that although AI can outperform humans on some tasks, today's AI fails miserably at other tasks that humans perform. A casual review of current developments suggests that over the near term AI may be able to completely automate some jobs of drivers and warehouse workers, but most AI applications are targeted toward automating just some subset of tasks performed by specific occupations*".

In his work, Halal (2013) focuses on the same direction of the creation of new jobs, largely unknown to this day, who expresses the view that "*we can expect good virtual assistants to take over routine service tasks, but people will always want a real person to provide human contact*". Staff is growing rapidly in universities, hospitals, research institutes, and other advanced settings for these reasons. Unlike those who claim that the prevalence of AI equals high unemployment, he believes that the **service and knowledge work sector** could grow dramatically to 50−60 percent by 2030. He justifies this view saying that AI can automate knowledge-based work. However, he believes that there is a lot more than knowledge itself, like the creativity, entrepreneurship, vision, collaboration, diplomacy, marketing, supervision, and other higher-order functions that are uniquely human. Thus, advanced AI may be able to solve tough problems, but it cannot provide vision, purpose, imagination, values, wisdom, and other capabilities that are essential for sound leadership and tough choices.

Between the two aforementioned trends, Halal, Kolber & Davies (2016) present a balanced analysis, describing two perspectives: The Growth and Crisis. The Growth view argues the case for optimism while the Crisis perspective focuses on the looming threat of mass unemployment.

In conclusion, in relation to the above views, many of which speculate that routine work or non-productive or repetitive work actually performed by humans will be replaced by machines and automation, which we already see happening to a large extent (e.g. automated manufacturing), as well as others insisting on the constant need of human presence or the transition to occupations with a stronger focus on the provision of services and those based on knowledge, we keep in mind the following:

(a) "*we are in uncharted territory*" which means that we don't know for sure what will happen in the future labour market
(b) "*the replacing time of jobs* [by AI] *is the critical point*" implying that it is "unknown" when jobs will be replaced by machines and automations based on AI technologies
(c) many of the new jobs may not be "*accessible to people with average capability, even with retraining*" which raises concerns, given that lifelong education and training may not be sufficient
(d) «*empathy and other interpersonal skills are as important as proficiency in language and mathematics in ensuring young people's employment prospects*" in the sense of moving a large number of employees to occupations that require the above social-emotional skills.
(e) «*AI may be able to completely automate some jobs but most AI applications are targeted toward automating just some subset of tasks performed by specific occupations*», which is confirmed in the cases that we know of to this day.
(f) "*The service and knowledge work sector could grow dramatically to 50−60 percent by 2030*", which we see happening.

2.2 Indicative areas of application of AI technologies

In this section we attempt a rough reference to sectors/industries where AI technologies are applied. AI technologies, areas of application and sectors will be indicatively and briefly presented below, as proposed by vendors, consultants, scientists and experts.

For example, according to Capgemini Consulting (2017) the series of key technologies commonly classified as AI, are as follows:

- Online virtual agent for customer service or human language interaction.
- Ability of computers to understand and interpret the spoken word.
- Interactions through natural language sentences and longer text.
- Provide context to decision-making by data analysis.
- Measurement of characteristics of human expressions and physical states to understand intent, emotion, age, etc.
- Analysis of images and video to interpret their content.
- Ability of computers to learn without being explicitly programmed.

- Algorithms inspired by the structure and function of the brain creating an artificial neural network.
- Use of a large group of autonomous agents; each contributing to solve a problem.

In this regard, the main fields of AI applications are the following:
(a) Natural Language that is referred to chat/voice bots, speech recognition, and natural language generation,
(b) Computer Vision and Biometrics Intelligence, which includes biometrics and image/video analysis and
(c) Technology Foundations analyzed in machine learning, deep learning and swarm intelligence.

In relation to the prevalence of ML in the last decades, there have been advances in fields related to Machine Learning (ML), including Data Mining, Machine Vision, Computational Statistics and other sub-fields of Artificial Intelligence (AI), in which efforts are explicitly dedicated to the development of algorithms that allow cognitive tasks to be automated. In addition, there are applications of ML technologies in Mobile Robotics (MR), and thus the extent of computerisation in manual tasks.

The survey by Capgemini in 2017 at 993 companies that are implementing AI, concluded that sectors of Telecom, Retail, and Banking have seen the highest implementation of AI at scale with percentages of 49%, 41% and 36% respectively. These sectors are followed by Utilities (34%), Insurance (31%), Automotive (26%) and Manufacturing (20%). On average, over a third (36%) of companies currently launching AI initiatives implement them at scale. In other words, they are going beyond small pilots and test projects and adopting AI applications at a larger scale. These sectors constitute areas of hiring personnel in AI job positions.

Professor Nikolaos Bourbakis indicatively mentions the following typical cases of AI applications:

- Brain and cognitive research
- Computer vision, image understanding and interpretation
- Video monitoring-surveillance understanding behavior
- Smart drones surveillance for securing borders
- Automated manufacturing and intelligent robotics
- Autonomous cars and optimized public bus services
- Smart appliances, smart houses and smart cities
- Intelligent data mining reducing processing time
- Automatic document processing and understanding
- Assistive technologies for people in need
- Automated healthcare services

- First responders assistance

It is worth mentioning here that certain technologies involving "intelligence" are gradually moving away from the AI umbrella, having become routine technologies, like the optical character recognition.

The Capgemini consulting company in the survey of 2017 (Capgemini, 2017) concluded that the application of AI in businesses has a serious impact in their internal learning processes, increases their sales and transforms their operations. More specifically, the business sector tries to learn from the AI application. One of the best ways to create this global learning loop on the business side is through the development of an AI-driven nerve center for managing operations. One global pharmaceutical company, for instance, developed what it calls its "*clinical control tower*" that continually updates and shares findings derived from the diverse data gathered from hundreds of clinical trials across thousands of sites around the world. This system enables decision makers to understand in detail what drives variations among clinical trials (in speed, quality, and cost) and delivers predictions that enable interventions to reallocate resources and avoid delays and waste.

Business sector due to AI is boosting sales. For example, Harley-Davidson used AI for highly targeted marketing activities, identifying customers who shared the attributes of previous high-value customers. The AI tool helped generate leads and also analyzed thousands of campaign variables to identify what worked and what didn't. This helped increase sales leads by 2,930% within three months.

Business sector is transforming operations due to AI. At JP Morgan, lawyers spent thousands of hours studying financial deals. Now, an AI system is doing the challenging job of interpreting commercial loan agreements, taking on a task that has swallowed 360,000 hours of work by lawyers and loan officers. The AI system reviews documents in seconds and is less prone to error. The system has cut down on loan-servicing mistakes, many of which originated from human error in interpreting 12,000 new wholesale contracts per year.

2.3 The impact of COVID-19 on AI

In a study by Pega systems "The future of work", a 2020 research study on the changing role of technology in the workplace, they found that at the start of the pandemic, organizations like Amazon, Facebook, and Google were praised for their quick switch to remote work. However, these organizations have proven to be outliers because most of the businesses were not prepared. Specifically, only 28% of the respondents in the research said their companies were "very well prepared" to deal with the COVID-19 pandemic. And one-third said they were "Not very" or "Not at all" prepared.

By following the same report by Pega systems it seems that the crisis exposed more IT gaps than expected, according to 74% of respondents. As a result, organizations are investing more heavily in AI tools that help them meet the needs of their customers, scale and adapt with intelligent automation. Today's investments in technology aim to improve efficiency, reduce costs, and benefit employees. Two-thirds of the respondents say employees are asking for better technology to improve how they work. To meet this need, companies are investing in a range of technologies, including the following: Business process management (BPM) software, Deep learning, Machine learning and Robotic process automation (RPA).

In a study by the Stanford University (Waikar, 2021) on the impact of the COVID-19 pandemic on the AI industry and the report of the "2021 AI Index", it is stressed that "*the AI industry witnessed strong hiring and investment growth during the pandemic. Across 14 countries analyzed, the AI hiring rate was 2.2 times higher in 2020 than 2016, on average*". Especially, hiring in the USA grew more slowly than in other countries, like Canada, Brazil, and South Africa. The U.S. saw a decrease in total AI job postings between 2019 and 2020 — from about 325,000 jobs to about 300,000 jobs. An explanation is that a lot of other countries are starting from a very small base, so there's a lot more room to grow.

Additionally, the results of McKinsey & Company Global Survey (2020) on AI suggest that organizations are using AI as a tool for generating value. Increasingly, that value is coming in the form of revenues. A small contingent of respondents coming from a variety of industries attribute 20 percent or more of their organizations' earnings before interest and taxes (EBIT) to AI. These companies plan to invest even more in AI in response to the COVID-19 pandemic and its acceleration of all things digital. This could create a wider divide between AI leaders and the majority of companies still struggling to capitalize on the technology; however, these leaders engage in a number of practices that could offer helpful hints for success. Still, while companies overall are making some progress in mitigating the risks of AI, most have a long way to go.

In general, work has not stopped even though physical offices may have closed due to COVID-19 crisis. Employees still need tools to help them stay productive and customers still expect businesses to answer their calls. Thus, businesses must meet the growing and changing needs of their employees and customers during the lockdowns. To do so, they have increased the use of and investment in: AI that fuels better decisions, Intelligent automation that can put real-time insights to work, and the Cloud solutions that enable quick and collaborative application development. These changes allow businesses to rapidly scale and adapt to the changing context of customers and employees (from disruption to transformation).

2.4. AI job opportunities in AI and salaries in the sector

Today, employees in AI applications usually have to handle complex problems. Thus, in their career they are more likely to apply their knowledge to interdisciplinary areas including robotics, business forecasting, intelligent search, video games, music and entertainment, chat bots, medical diagnostics, self-driving cars, to name a few. The current debate is about how deep and how fast intelligent machines will automate jobs, and whether the same technological forces will generate enough new work. Jobs in the AI industry are expected to increase by 2.3 million positions by the year 2030. According to a report produced by Capgemini's Digital Transformation Institute, 83% of companies that use AI technologies confirm that AI is already contributing to the creation of new jobs[3].

Views on the job professions that will be created in the future, as well as professions according to the current demand for jobs in the industry are shown in Table 1. For future jobs, a characteristic MIT Sloan analysis was made by Wilson, Daugherty, Morini-Bianzino (2017). They have conducted a global survey of more than 1,000 large companies already using or testing AI and ML systems. They identified the emergence of entire categories of new, uniquely human jobs. These roles are not replacing old ones. They are novel, requiring skills and training that have no precedents. In brief, these new proposed professions refer to "trainers" – "explainers" – "sustainers" and they are analyzed here below.

Table 1. Categories of new jobs (Source: Wilson, Daugherty, Morini-Bianzino, 2017)

Trainers	Customer-language tone and meaning trainer	Teaches AI systems to look beyond the literal meaning of a communication by, for example, detecting sarcasm
	Smart-machine interaction modeler	Models machine behavior after employee behavior so that, for example, an AI system can learn from an accountant's actions how to automatically match payments to invoices
	Worldview trainer	Trains AI systems to develop a global perspective so that various cultural perspectives are considered when determining, for example, whether an algorithm is "fair."
Explainers	Context designers	Designs smart decisions based on business context, process task, and individual, professional, and cultural factors
	Transparency analyst	Classifies the different types of opacity (and corresponding effects on the business) of the AI algorithms used and maintains an inventory of that information.
	AI usefulness strategist	Determines whether to deploy AI (versus traditional rules engines and scripts) for specific applications.
Sustainers	Automation ethicist	Evaluates the noneconomic impact of smart machines, both the upside and downside.
	Automation economist	Evaluates the cost of poor machine performance.
	Machine relations manager	"Promotes" algorithms that perform well to greater scale in the business and "demotes" algorithms with poor performance.

"Trainers" describe a role that humans will undertake to teach AI systems, like Alexa and Koko algorithm, regarding the emotions behind questions made by humans to machines. Namely, the human tone of voice, the expression of speech, the emotions behind words themselves. For

[3] https://www.techrepublic.com/article/83-of-companies-using-ai-said-it-is-creating-new-jobs-but-theres-a-catch/

example, a person who has lost their suitcase is obviously under stress, or similarly someone who buys a product that proves to be defective, or someone who is about to take an exam is stressed. This type of emotions must be taught to AI systems so that they can react appropriately. The goal is for the system to be able to talk people through a problem or difficult situation using the appropriate amount of understanding, compassion, and maybe even humor. Whenever Koko responds inappropriately, a human trainer helps correct that action — and over time, the ML algorithm gets better at determining the best response.

Another future human role according to the aforementioned survey is the "explainers". The explainers will bridge the gap between technologists and business leaders. Explainers will help provide clarity, which is becoming all the more important as AI systems' opaqueness increases. Many executives are uneasy with the "black box" nature of sophisticated ML algorithms. These persons will get the proper training, for example coroners are highly specialized in order to perform an autopsy, so that they can explain how ML algorithms make decisions and be given what the European Union is looking for in AI, i.e. the "right to explanation".

Finally, MIT work proposes a new work role, that of "sustainers". The sustainers will help to ensure that AI systems are operating as designed and that unintended consequences are addressed with the appropriate urgency. In the survey contacted by MIT (Wilson, Daugherty, Morini-Bianzino, 2017), they found that less than one-third of companies have a high degree of confidence in the fairness and auditability of their AI systems, and less than half have similar confidence in the safety of those systems. In this regard, sustainers will play a crucial role. One of the most important functions will be the ethics compliance manager, if, for example, an AI system for credit approval was discriminating against people in certain professions or specific geographic areas, or …etc. These workers have to uncover the underlying reasons for such results and then implement the appropriate fixes.

For the aforementioned future professions, there are currently no clear educational pathways or relevant studies. However, as the authors state, the role of Trainer in particular could be taken on by persons without a college degree, as long as they have a high degree of inherent empathy (a characteristic that's measurable) at a personal level. In this case, this kind of professionals could be taught the necessary skills in an in-house training program. On the contrary, a number of new jobs, like, for example, sustainers (i.e. ethics compliance manager) are likely to require advanced degrees and highly specialized skill sets. The aforementioned authors conclude that, as with so many technology transformations, *the challenges are often more human than technical*.

In order to examine the current job demand, we should take into account that in the first decades of the 21st century, highly mathematical statistical ML has dominated the field of AI, and thus many jobs refer to AI/ML applications. Or in other words, in the first decades of the 21st century, highly mathematical statistical machine learning has dominated the field, and this

technique has proved highly successful, helping to solve many challenging problems throughout industry and academia. In this context, a general categorization of jobs could be (a) those related to ML applications, and (b) those requiring more specialized knowledge on designing and developing applications, as seen below:

1. ML engineers mainly employed in productionize web services. These jobs cover about 90% of the demand.
2. Data scientists, usually domain experts in modelling data and collaborate with ML engineers to productionize services / web-services. Usually, a PhD degree is required for these jobs.

A career in artificial intelligence can be realized within a variety of settings including private companies, public organizations, education, the arts, healthcare facilities, government agencies and the military. Some positions may require security clearance prior to hiring depending on the sensitivity of information employees may be expected to handle. Examples of specific jobs held by AI professionals according to the https://www.computersciencedegreehub.com/faq/skills-job-artificial-intelligence/ include the following:

- Software analysts and developers.
- Computer scientists and computer engineers.
- Algorithm specialists.
- Research scientists and engineering consultants.
- Mechanical engineers and maintenance technicians.
- Manufacturing and electrical engineers.
- Surgical technicians working with robotic tools.
- Medical health professionals working with artificial limbs, prosthetics, hearing aids and vision restoration devices.
- Military and aviation electricians working with flight simulators, drones and armaments.
- Graphic art designers, digital musicians, entertainment producers, textile manufacturers and architects.
- Post-secondary professors at technical and trade schools, vocational centers and universities.

A more general categorization of AI professions, as the demand for executives/employees is expressed today, is indicatively the following

- AI Data Analyst
- Robotics Scientist
- Machine Learning Engineer
- Data Scientist
- Business Intelligence Developer
- Research Scientist

- Big Data Engineer

In general, AI is highly scientific. The skills that an engineer will need to pursue AI as a career are varied, but all of them require a great deal of education, training and focus. There is a wide variety of career types available in AI and ML, and they range from higher-level research to low-level programming and implementation. For example, **researchers** use their breadth of knowledge in theory and study to reveal new types of systems and capabilities. Researchers hypothesize new or different ways for machines to think and test their research for real-world feasibility. **Algorithm developers** take AI research and transform that research into repeatable processes through mathematical formulas that can be implemented using hardware and software. **Software developers and computer scientists** use those algorithms to write sophisticated pieces of software that analyze, interpret and make decisions. **Hardware technicians** build pieces of equipment (like robots) to interact with the world. Robots use its internal software to move and operate.

According to the "2020 USI Master Survey (2015 – 2019)" by the University of Switzerland Università della Svizzera Italiana the average annual salary in the AI sector is around 75,000 Swiss francs, without specifying exactly which of the aforementioned AI specializations it refers to. According to Datamation.com[4], in the San Francisco area the salaries range from approximately $134,135 per year for software engineer to $169,930 per year for machine learning engineer, with the top earners in ML making more than $250,000, according to a previous salaries analysis from published data of Indeed.com[5].

According to a posting of Expatinvestots.com[6] in 2018 even biggest and most prominent tech giants are complaining about the difficulty hiring AI engineers. The demand has pushed salaries to absurd heights. The New York Times' insight into AI industry reveals that sometimes people with just a few years of experience can expect base pay of between $300,000 and $500,000 a year, while the very best will collect millions. One independent AI lab told the publication of Expatinvestors.com that there were only 10,000 individuals worldwide with the right skills to spearhead serious new AI projects. Most desperate countries for AI and ML engineers according to aforementioned source are USA, Europe (Sweden has the most severe tech talent shortage, Germany), UK, China, Canada and India. The difficulty in finding suitable staff is so big that, for example, tech giants like Amazon, Google, Microsoft, etc. in the US, have postings in the personnel recruitment system (Career Advisory Platform) of Paysa with the following aggregate net salaries:

• Amazon: $227,769,001

[4] https://www.datamation.com/artificial-intelligence/artificial-intelligence-salaries-paychecks-heading-skyward/
[5] Indeed.com: Worldwide employment website for job listings
[6] https://expatinvestor.com/articles/opportunities-for-ai-machine-learning/

• Google: $130,048,389

• Microsoft: $75,158,057

• Facebook: $38,636,827

• NVIDIA: $34,280,190

It is obvious from the above outrageous salaries that the world tech leaders are in a fierce competition for the best talent and won't hesitate to pay whatever it takes to recruit skilled specialists.

Other top recruiters in USA are Intel, Rocket Fuel, General Electric, Cylance, Oculus VR, Booz Allen Hamilton, Huawei, Adobe, Accenture, iRobot, Magic Leap, Rethink Robotics, BAE Systems, HERE, IBM, Samsung, Lenovo, MoTek Technologies, Uber, PCO innovation, Rakuten Marketing, and Wells Fargo. Additionally, the country is estimated to have 2,500,000 open data science jobs by 2024.

On the other hand, the most demanding high-tech jobs in Europe are:

- Artificial intelligence and deep machine learning
- Cloud security/encryption
- Robotics
- Blockchain/fintech
- Game developers

European countries are forced to recruit skilled specialists from outside the EU to fill the vacancies. EU member-countries are in strong competition not only with global leaders such as the USA, but with each other as well. To battle the skill shortage, Finland's digital game industry is aggressively recruiting digital experts from India, China, Russia and the United States.

By 2030, Germany could face a shortage of 3 million skilled workers, according to recent research by Economic Research Institute Prognos AG, and a considerable number of them are IT, Machine and Automobile building professionals[7]. Their main worry in Germany is that a skill

[7] https://www.linkedin.com/pulse/germany-would-require-three-million-skilled-workers-2030-sonia-mishra/

shortage is the biggest obstacle on the way of developing and implementing AI and machine learning technology. Four out of five companies say the difficulty they have in finding skilled workers is preventing them from investing in innovation.

In addition, China is actively investing in AI sector and implementing the technology. Chinese AI enterprises now lead global AI development, with the help of an immense amount of talent, a large market and strong support of venture capital (https://www.eurobiz.com.cn/innovative-ai-applications-china/). China is the second largest AI market, only surpassed by the United States, in terms of the number of enterprises, patents and financing. In China, approximately 50 per cent of AI companies focus on machine vision, service robots and natural language processing. As the gathering place of AI innovation, almost 80 per cent of these companies have their base of operations in Beijing, Shanghai and Shenzhen. However, China is facing the same problem as other countries, albeit on a bigger scale: a shortage of around 5 million AI talents. People with expertise in AI are in huge demand in China. Domestic job market is unable to fill the huge amount of advertised positions. Specialists with five years of experience available for employment are a rare commodity, so Chinese companies are looking for such people all over the world. Baidu Inc, for example, launched a new round of overseas recruitment searching for talent in nine top universities in the US, to fill positions related to machine learning, data mining and computer vision algorithms. Consequently, high demand has sent AI engineer salaries skyrocketing in China. IDG Capital's 2017 Internet Unicorn Salary Report (www.idg.com) revealed that pay packages for top AI positions were 55% higher than average ICT industry employee salaries, 90% higher at intermediate positions, and 110% higher at junior positions.

2.5 Technical Skills

If we want to describe the technical skills required by the labour market for someone to work in the AI/ML sector, we should first take into account the risks undertaken: (a) to formulate skills that may have changed in a relatively short period of time due to the fast progress of technology; (b) not to take into account skills required by new professions created in the AI/ML sector, and (c) not to describe all technical skills due to the scope of Artificial Intelligence. Keeping in mind the above risks, we will present certain views on the most important technical skills for a career in the specific sector.

It is generally true that the entry level positions require at least a bachelor's degree while positions entailing supervision, leadership or administrative roles frequently require master's or doctoral degrees.

The most common factor in all career fields in AI is that they all require a great deal of experience in math and science-related topics. The top AI skills are the following:

- Programming languages (Python, R, Java are the most necessary)
- Linear algebra and Statistics
- Signal processing techniques
- Neural network architectures

Indicatively, the ML engineers must possess strong software skills, be able to apply predictive models, and utilize natural language processing while working with massive data sets. Also, machine learning engineers are expected to know software development methodology, agile practices, and the complete range of modern software development tools right from IDEs like Eclipse and IntelliJ to the components of a continuous deployment pipeline. Hiring companies prefer candidates holding a master's or doctoral degree in computer science or mathematics with working knowledge of modern programming languages like Python, Java, and Scala.

Accordingly, Data Scientists collect, analyze, and interpret large amounts of data by using machine learning and predictive analytics to gain insights beyond statistical analysis. They should have expertise in using Big Data platforms and tools, including Hadoop, Pig, Hive, Spark, and MapReduce. Data scientists are also fluent in programming languages, including structured query language (SQL), Python, Scala, and Perl, as well as statistical computing languages. Data scientists are highly educated, with the majority holding a Master's or Doctoral degree, though an advanced degree in computer science is preferred, it is not a prerequisite. The most desired technical skills are in-depth knowledge of SAS and R, Python coding, Hadoop platform, experience working on cloud tools like Amazon's S3, and the ability to understand unstructured data.

More specifically, for technical skills we would like to make the following comments:

- **Programming languages.** Python is the most popular/used programming language, along with R, Java, Javascript, C++, C, Scala, TensorFlow, etc. While Python is the most common language among ML repositories on GitHub, Scala is becoming increasingly common, especially when it comes to interacting with big data frameworks such as Apache Spark. Some job opportunities might need experience in low-level programming languages like Python or MatLab. Others, especially in the healthcare industry, need expertise in data services like Spark and Blockchain.
- **Linear Algebra, Calculus and Statistics**. It is recommended to have a good understanding of the concepts of Matrices, Vectors, and Matrix Multiplication. Moreover, knowledge in Derivatives and Integrals and their applications is essential to even understand simple concepts like gradient descent. Whereas statistical concepts like Mean, Standard Deviations, and Gaussian Distributions, graphical representation tools like Boxplot and Histograms, along with probability theory for algorithms like Naive Bayes, Gaussian Mixture Models, and Hidden Markov Models are necessary to thrive in the industry.

- **Applied Math and Algorithms**. This skill set will enable understanding subjects like Gradient Descent, Convex Optimization, Lagrange, Quadratic Programming, Partial Differential equation, and Summations.
- **Neural Network Architectures**. Machine Learning is used for complex tasks that are beyond human capability to code. Neural networks have been understood and proven to be by far the most precise way of countering many problems like Translation, Speech Recognition, and Image Classification, playing a pivotal role in the AI department.
- **Data engineering**. The first step in ML development is pre-processing and storing raw data generated by systems. For example, let's imagine an online store that sells a variety of products to customers around the world. This online store will create lots of data related to particular events. For storing data, an engineer could use object storage, such as AWS S3 or a data warehouse such as AWS Redshift.
- **Advanced Signal Processing Techniques.** ML has feature extraction as one of its integral aspects. For mastering this, engineers need to be familiar with solving different problems through advanced signal processing algorithms such as bandlets, wavelets, curvelets, shearlets, contourlets, etc. In addition, they should have a core understanding of time-frequency analysis and discover ways to implement it for their problems. Also, they should be well-versed with concepts like Convolution and Fourier Analysis.

Additional useful technical skills are the following:

- **Basic Computer Science knowledge**
- **Web service development**
- **Cloud technologies literacy**
- **Modern web service/application architecture**
- **Knowledge of ML libraries (e.g. MLlib, Scikit)**
- **Modern tools/ concepts,** like:
    a. Kubernetes (see https://kubernetes.io/)
    b. Docker (see www.docker.com)
    c. CICD pipelines (i.e. DevOps, see devops.com)
    d. Version control systems (VCS)
    e. Object Oriented programming

In addition, today, the role of a ML/AI Developer is becoming a strategic necessity for most organizations. There are several skills that developers need to make the biggest impact possible in this role. There are a few skills that are specific to ML engineers only. These skills are the following:

- **Natural Language Processing (NLP):** It is a fundamental part of ML, and studies how machines understand and interpret human language. There are several libraries such as Gensim and NLTK that provide the NLP'S foundation and contain different functions to help computers

understand our language. This is accomplished by breaking down the text according to its syntax, extracting important phrases, removing unnecessary words, and so on.

- **Reinforcement learning**: It is the primary reason behind the sudden improvements in deep learning, and has the potential to revolutionize Robotics in the foreseeable future.

3. Comments and Conclusions

As shown above, some strongly claim that the prevalence of AI will have a negative impact on employment in the coming years, although some views insist that humans are the ones who create automations, algorithms and machines and that creativity, imagination, entrepreneurship, vision, collaboration, diplomacy, marketing, supervision and other high-level skills will always be necessary despite the prevalence of AI. The impact on employment may relate to the reduction of jobs in some routine cases, although there seems to be a shift of jobs towards administration tasks and services that require more human intervention, administrative, social and emotional skills and empathy. At the same time, it appears that people's fear of major unemployment is not justified at present, because computers and algorithms only perform a very small part of certain tasks and human work is indispensable for companies and organizations.

At international level, companies are distinguished in a few tech giants based in the USA and China, followed by companies (usually with a global presence) in the form of early-adopters for AI/ML technology applications. In addition to the above, most companies across all countries and continents have not yet discovered/adopted any AI/ML technology, thus making us believe that the use of AI/ML technologies will continue and increase in the future, for the needs of even small/smaller companies other than tech giants and globally present companies. Already, the demand for jobs is extremely high and is covered by an international pool of a few thousand specialized executives who move from one country to another or from one continent to another or even work remotely, especially after the COVID-19 pandemic and the subsequent lockdowns. Due to the high demand, salaries are particularly high and, in some cases, outrageous. Of course, salaries vary depending on the country and they are always adapted to the applicable wage framework, as described for the case of Switzerland and the USA.

In regards to the technical skills required by the labour market, these vary depending on the needs of companies/organizations, but they definitely refer to the use of specialized software, the utilization of mathematics and statistics and a set of tools-languages and/or software use/utilization/development environments. Jobs require a university degree and several specialized technical skills. These jobs are addressed to scientists who are specialized in the peak of today's technological advancement. Of course, the authors believe that the specific needs of a company may be met by internal education and training schemes of the existing or newly-hired personnel.

Conversely, it appears that in the future there will be a new range of specialties/professions in the sector, as proposed by MIT and other parties, that were not analysed in this text, that will require human presence. In addition to technical skills, these specialties are also associated with certain human attitudes (e.g., emotion), competences (e.g., communication, administrative skills) and values (e.g., ethics), thus leading to the conclusion that, in the future, informally acquired social-emotional skills will be more useful than ever. As already discussed, MIT and the Advisory Group of British Educators and CEOs encourage educational organizations and institutions that decide on educational matters to clearly and specifically teach social-emotional skills at all school levels as an absolute necessity for the future.

In this light, AI along with any technologies it includes today or will include in the future, as a human creation, cannot be harnessed and/or used in the absence of the human factor who will monitor, supervise, fix, improve, adapt, evaluate and finally confirm the correct operation of machines and algorithms.

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