Artificial Intelligence Trends and Future Scenarios: Relations Between Statistics and Opinions

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***Abstract*—Artificial Intelligence (AI) is a trend in innovation and research expected to significantly impact society and firms. However, there are various opinions about its possible effects. This study compares the World Intellectual Property Organization (WIPO) statistics with opinions from 21 AI researchers, self-identified as professors and postdocs. Within AI-based innovations, WIPO data shows that Deep Learning is the technique with the largest average growth rate in recent years. Similarly, AI researchers consider that Deep Learning is a strong trend in AI. The survey also revealed that perceived AI research trends are somewhat different from ideal AI research trends. Ideal trends include AI fundamental research, ethics, data usage, human-machine interaction, learning, and good practices. In addition, 181 self-identified professionals, professors, postdocs, and doctoral students, among others involved in AI communities, shared their opinion on the impact of AI and the possible future scenarios. Most respondents identified pragmatics (57%), while very few were pessimists (4%), among other options.**

***Index Terms*—Artificial Intelligence, Trends, Future, Impact**

I. Artificial Intelligence Trends

In the last years, the interest in harnessing AI for research and innovation increased dramatically [1], [2]. In 2019, WIPO reported that, remarkably, 50% of all AI patents were published since 2013, such that there are about 0.34 million AI-based patents and more than 1.6 million scientific publications [1]. AI innovations are expected to promote economic growth [3], [4]. At the same time, some authors worry that AI innovations replace workers on a massive scale [5]. Furthermore, experts recognize that the wide adoption of AI technologies should be accompanied by policies and regulations that promote ethical use of AI [1].

This study summarizes the findings of WIPO statistics concerning trends in AI for innovation and compares them with the perception of 21 surveyed AI researchers. In addition, this work reviews the literature on the impact of AI and presents the opinions of 181 respondents involved in AI communities surveyed in 2020.

A. AI Innovation statistics

The number of scientific papers and patents increased significantly since 2016. WIPO's AI trends analysis considers three dimensions [1]: (1) techniques used, (2) functional applications, and (3) application fields. WIPO reported that the most important techniques used according to the average annual growth rate between 2013 and 2016 are Deep Learning (175%), Multi-task Learning (49%), and Neural Networks (46%). Figure 1 shows the trend for Deep Learning in innovation and research in the last years.

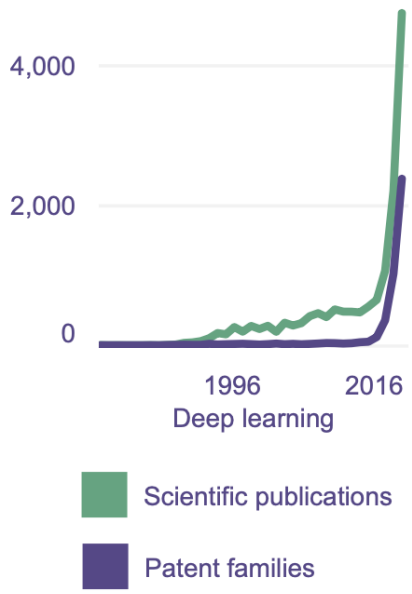

Fig. 1: Deep Learning patents by earliest priority year and scientific publications year, taken from [1].

Within functional applications, Computer Vision is the category with the largest number of patent filings in 2016 (21 011), four times the number of Natural Language Processing (NLP) filings, the second-largest category, see Figure 2. However, Robotics (more than 2 thousand) and Control Methods (less than a thousand) grew annually, each category, by 55% between 2013 and 2016. Finally, the most important application fields in terms of the number of patent filings in 2016 were Transportation (8 764), Telecommunications (6 684), Security (more than 4 thousand), Life and Medical Sciences (4 112), and Personal Devices, Computing and HCI (less than 4 thousand) see Figure 3.

B. AI Trends survey

In 2020, an online survey called AI Trends was advertised in the following communication channels: *Machine Learning News, ISMIR Community Announcements, Women in Machine Learning,* and *Women in Music Information Retrieval* [6].

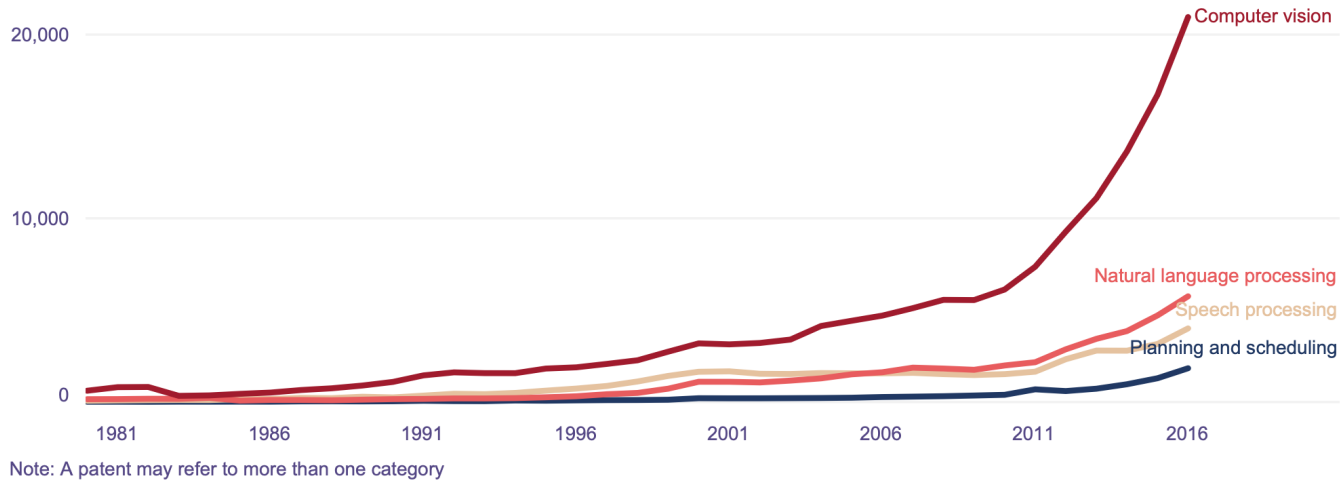

Fig. 2: AI-based functional applications number of patents by earliest priority year, taken from [1].

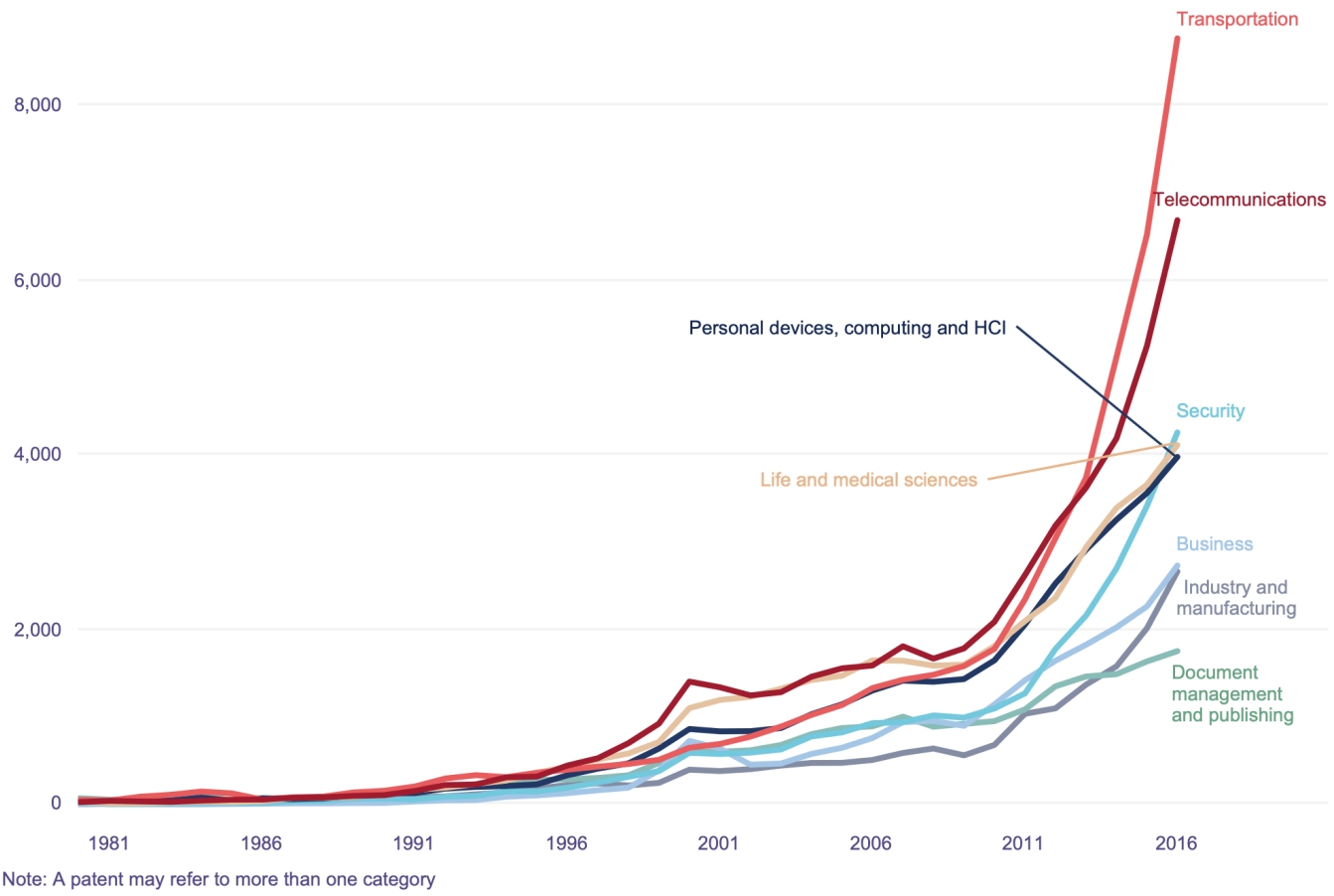

Fig. 3: AI-based patents by application fields by earliest priority year, taken from [1].

Twenty-one voluntary and anonymous responses were collected from self-identified postdocs and professors. Five participants identified as female, 14 as male, and 1 as non-binary. Participants were located in Africa (2 postdocs), America (4 professors and 3 postdocs), Asia (4 professors), and Europe (3 professors and 5 postdocs).

Figure 4a summarizes the responses as a word cloud to the questions: *"In your opinion, what are the Top 5 trends in AI research?"* While Figure 4b summarizes the responses to the question: *"What should be the Top 5 priorities in AI research?"*

The survey openly asked about AI trends without mentioning the three dimensions considered by WIPO (techniques used, functional applications, and application fields). The surveyed researchers coincide with WIPO statistics in that Deep Learning is a relevant trend in AI research. While reinforcement learning was perceived as a trend, this is not reflected in WIPO data. Reinforcement Learning might have attracted attention after 2016, thus not yet reflected in the WIPO report as a trend. Interestingly, to the first question: *In your opinion, what are the Top 5 trends in AI research?"*, functional applications appeared more frequently in the answers (Computer Vision, Natural Language Processing, Robotics). At the same time, to the second question, researchers gave more importance to ethics, data, the world, the relation between humans and machines, and the relevance of a better understanding of AI. The ideal emerging trends are listed as follows:

- **AI and Learning** were linked to machine learning, deep learning, reinforcement learning, transfer learning, alternatives to deep learning, and scalable machine learning. Learning was also related to the study of the brain, cognition, and learning mechanisms. Respondents often stressed understanding AI to promote and ensure good practices for explainability, reproducibility, generalizability, robustness, safety, and trust.
- **Ethics and Society** were also trend. Ethics per se was a relevant trend, frequently mentioned in the responses. The societal impact was related to policy and regulation in general. More specifically, economic regulation for social equality, and its relation to bias, calibration, and control mechanisms to prevent tax evasion, fraud, or corruption.
- **Human-Machine Interaction** or Human-Computer Interaction were related to decision-making, and the integration of intelligent agents for work and daily life, also in critical systems (e.g., autonomous vehicles or nursing robots). Respondents also mentioned embodiment and the study of human features in an automated world.
- **Data** was also frequently mentioned, together with data analysis, big data, dimensionality, data understanding, and data mining.
- **Applications fields** of interest were healthcare and life sciences, banking and finance, industry, labor market forecasting, market disruption, privacy, climate change, energy management, and collective transportation.
- **Funcional applications** of interest were Robotics, Computer Vision, and Natural language processing.

There might be various reasons why there was a difference between perceived AI trends and ideal AI trends. For example, it could be that research projects respond to plans outdated by new research challenges or that building new expertise requires some time. Besides, it may be possible that research funding relates more to innovation and commercialization than to ideals.

II. Possible Future Scenarios

We are in the middle of an industrial revolution, also called the "AI Revolution" [7], expected to have an impact more significant than that of past industrial revolutions [7]–[11]. However, there is no consensus on whether AI adoption will be overall more positive than negative in general [7], [8], [11]–[14]. Spiros Makridakis, a forecasting expert, categorized expert opinion on the impact of AI into optimist, pessimist, pragmatic, or doubter, and perceived that most researchers could be recognized as pessimists and least of them as pragmatics [7].

A. Productivity and wealth gaps

WIPO data reflects strong investments and confidence in AI. Economists argue that the productivity increase will be related to intelligent automation for solving tasks cheaper and faster, while decision-making will remain as a human activity that will increase its value [14]. Positive predictions estimate that AI will contribute USD 15.7 trillion to the world economy by 2030 [3], and there are three arguments for economic growth potentiated by AI [4]:

- first, intelligent algorithms are a virtual workforce,
- second, AI innovations can help workers to be up to 40% more productive, and
- third, AI innovations can create new revenue streams.

However, other experts expect massive unemployment in short periods of time and warn that intelligent automation will replace workers such that some occupations will disappear, representing a problem that could worsen opportunity gaps [5]. Some studies estimate that by 2030, AI innovations could displace 10% of workers with high education, 35% with medium education and 40% with low education; and the most affected sectors will be transportation (up to 50% displaced workers), finance (30%), and health care (20%) [15]. Therefore, a recurrent pilar in AI national strategies is education [6].

The analysis of previous industrial revolutions indicates that innovations boost productivity, and more jobs might be created than lost. Still, it was also observed that countries adopting key technologies timely are those benefiting the most [7]. Therefore, wealth gaps can worsen between the technologically ready and the rest. It might not be casual that high-tech countries show low unemployment rates. For example, in the manufacturing sector, South Korea, Singapore, Germany, and Japan were the countries with the largest number of industrial robots installed per 10 000 workers in 2016 [16]. At the same time, these four countries had the lowest unemployment rates in 2016 [17].

(a)

(b)

Fig. 4: (a) Word cloud answers to the question: *"In your opinion, what are the Top 5 trends in AI research?"* (b) Word cloud answers to the question: *"What should be the Top 5 priorities in AI research?"*, based on data from [6].
Data available at: http://gvelarde.com/a/data.html.

B. Technology as a tool

Technology and tools development help us solve problems ranging from using a stone to crack a nut to using telescopes to observe the universe. A piece of paper and a pen help us augment our capacity of keeping ideas we want to recall in the future. A smartphone is another tool that expands our ability to perform different tasks, such as saving thousands of phone numbers and retrieving them when needed or using Global Positioning System (GPS) technologies to travel and reach our destination. Technology is an aid to augment or senses, actions, or cognitive abilities. Intelligence augmentation can be used to support decision-making, cognitive overload, information processing, attention, and memory [18].

C. Regulations and Control

The wide adoption of AI-based technologies raises serious concerns about regulation and control. The Organisation for Economic Co-operation and Development proposed five principles for trustworthy AI [19]

- first, considering beneficial development for people and the environment (the planet),
- second, respecting "the rule of law, human rights, democratic values and diversity [...] to ensure a fair and just society",
- third, ensuring transparency for people understanding AI developments,
- fourth, ensuring robustness, safety, and risk management,
- fifth, ensuring responsibility and accountability for proper functioning.

The G20 adopted these principles in 2019. Policymakers and AI strategists will have to stay tuned to AI developments in research and innovation to ensure trustworthy AI adoption.

D. Human intelligence and Artificial Intelligence

Intelligence is studied actively and has been approached from different fields, including psychology, neurology, biology, philosophy, anthropology, and computer science [20]–[25]. A widely accepted definition of intelligence, states that [20]:

> Intelligence is a very general mental capability that, among other things, involves the ability to reason, plan, solve problems, think abstractly, comprehend complex ideas, learn quickly and learn from experience. It is not merely book learning, a narrow academic skill, or test-taking smarts. Rather, it reflects a broader and deeper capability of comprehending our surroundings —"catching on", "making sense" of things, or "figuring out" what to do.

In computer science, AI is defined as [25, p. 5]:

> The study of the computations that make it possible to perceive, reason, and act.

Today, Narrow AI or Weak AI refers to algorithms exhibiting "intelligent" abilities to solve a specific task. In contrast, an algorithm showing general intelligence would be recognized as Artificial General Intelligence (AGI), and intelligence that could match the highly adaptable human intelligence even for environments not contemplated by their creators [26].

Some authors do not consider it probable that algorithms can mimic human reason. Dreyfus explains that human intelligence relies on unconscious processes that can not be captured by conscious symbolic information processing and finds it fascinating and helpful for research that technology reveals their limits [27]. However, there are large investments in projects trying to mimic the brain, such as the Human Brain Project that investigates the effects of fussing biologic neurons with computers called neuromorphic. This project started in 2013 and in 2020, the European Commission provided another 150 million Euros funding until 2023 [28]. The International Conference on Neuromorphic Systems published 20 research papers in 2020 and 29 research papers in 2021 [29].

E. Futurism

Utopian optimists picture a future of unlimited wealth achieved thanks to AI and other technologies in the long term [7]. In contrast, other philosophers wonder if AI could reach Artificial General Intelligence (AGI), followed by superintelligence, an intelligence superior to that of the most brilliant minds, so that it would be threatening for humans if its objectives are not aligned with those of humanity [12].

F. AI Impact Survey

The open questions (*"In your opinion, what are the Top 5 trends in AI research?"* and *What should be the Top 5 priorities in AI research?*) were removed from the AI Trends survey, given that a shorter survey could potentially receive more responses. This new reduced survey was called AI Impact. In total, 181 anonymous and voluntary responses were recorded. The invitation to participate was sent online in 2020 to the same communication channels: *Machine Learning News, ISMIR Community Announcements, Women in Machine Learning* and *Women in Music Information Retrieval* [6].

Forty-three percent of the respondents self-identified as female, 55 as male, 2% as non-binary (genderqueer), and less than 1% as genderless. Participants reported being located in Europe (41%), America (29%), Asia (19%), Africa (8%), Oceania (2%), and Asia-Europe (less than 1%). Respondents self-reported as Professionals (27%), PhD students (24%), Graduate students (18%), Professors (16%), Postdocs (11%), Independent Researchers (2%), Non-graduate students (1%) and Unemployed (1%), see Figure 5.

The question: *"Which option describes you best?"* showed the following options [6]:

- "OPTIMIST: AI will help us solve the most challenging world problems and will bring us closer to live in a world of unlimited wealth globally. In the future, we will enjoy the broad adoption of intelligent automation, and humans will work only on tasks of their preference."
- "PESSIMIST: AI could be our last invention. Artificial General Intelligence may occur in the future. Optimists underestimate the problems associated with superintelligence dominating humans. Since in the future, intelligent

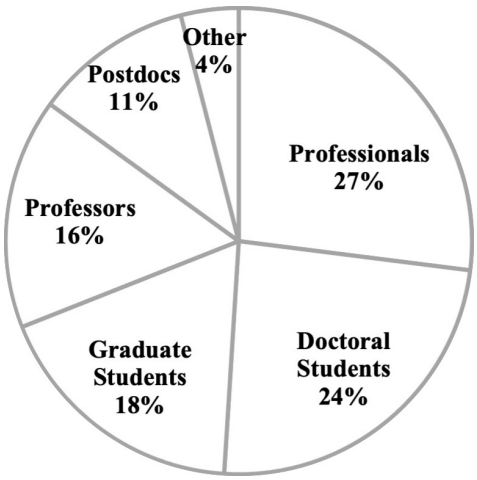

Fig. 5: Respondents occupations, based on data from [6].

machines will take all important decisions for us (humans), we will be just a second class entity and many people will not be motivated to work."

- "PRAGMATIC: AI will potentiate economic growth where applied; it will increase labor productivity and will create new revenue streams on diverse areas. Some jobs will be lost, but more jobs will be created. Decision-making will increase its value and will remain as a particular task performed by people, not machines. The wealth gap may widen between those exploiting AI benefits and those who do not. Effective regulations will control AI and its dangers. Research on human intelligence augmentation will be fundamental."
- "DOUBTER: Artificial General Intelligence will never happen, such that AI will never outperform biological intelligence. Therefore, we should not consider AI as a threat to humans."
- "Other: (your answer)"

As seen in Figure 6, most respondents self-identified as Pragmatics (57%), followed by Optimists (22%), Others (9%), Doubters (8%) and Pessimists (4%).

Philosophers Vincent Müller and Nick Bostrom surveyed 170 selected experts between 2012 and 2013. Most surveyed selected experts considered that Artificial General Intelligence could occur by 2075 with a 90% probability. In addition, most experts (40%) expected a positive impact, about 20% expected an extremely positive impact, about 15% predicted a neutral effect, while less than 10% expected extremely bad or catastrophic implications [30]. Thus, the results of the survey presented here are consistent with those obtained by Müller and Bostrom in that most respondents expect a positive impact possibly equivalent to what self-identified pragmatics expect, and only a minority would predict an extremely bad impact, comparable to what self-identified pessimists would anticipate.

III. Conclusion

WIPO statistics provide a valuable overview of technology trends. Without a doubt, AI adoption has been critical in

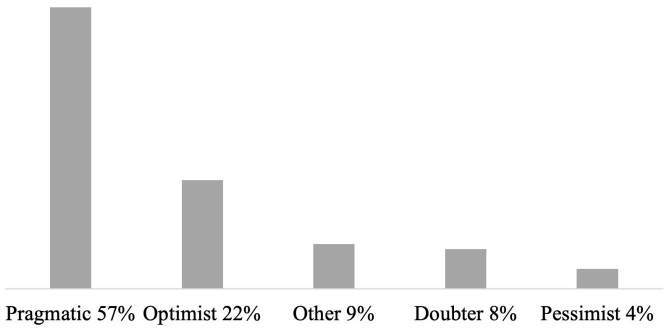

Fig. 6: Responses to the question: *"Which option describes you best?"*, based on data from [6].

recent years, and almost 90% of all AI patents use machine learning [1]. Deep Learning is the technique used with the largest growth in recent years, and it was perceived as such in the survey. In addition, the survey revealed that perceived AI research trends are somewhat different from ideal AI research trends. Among ideal AI trends emerged: ethics, data usage, human-machine interaction, learning, together with a profound understanding of AI in theory and practice, its regulation, explainability, reproducibility, trust, and safety. Most surveyed researchers are aware that AI could potentiate economic growth, and although some jobs will be lost due to intelligent automation, researchers trust that more jobs will be created. Still, they are aware that wealth gaps may worsen between those harnessing AI innovations and those who do not. Researchers consider relevant AI regulations and control, as well as further research on human intelligence augmentation. Few surveyed researchers believe that AI could have terrible consequences for society.

IV. Acknowledgments

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