Ethics, Data Science and Networked AI: Written Assignment

AI and Job Automatization: are some professions really doomed?
and
Cybernetic Proletarianization: The Degradation of Work Through Algorithmic Control

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***Abstract*—Artificial intelligence[1] (AI) and robotic systems are being deployed in more and more working environments, with more or less relevant economic and societal consequences. These systems contribute to the realization of the business goals of companies and, more generally, they are part of the consistent technological progress of the last decade and of the following ones. As their pervasiveness in the labor market is a supposedly inevitable phenomenon, this paper aims to deeply analyze what job automatization is, what it entails, how it is perceived and how it should be ethically approached in order to take its impact on society into account. Furthermore, we discuss the impacts technologies can have on the workplace. Scientific management brought a big change in the way people worked and cybernetic systems have amplified this effect even more. Using the concept of cybernetic proletarianization we discuss adverse effects of work regulation technologies to workers and the working class in total, which result in a significant loss of autonomy and a great increase in precarization.**

***Index Terms*—artificial intelligence, robotic systems, automation, regulation, cybernetics, proletarianization, labor**

I. AI and Job Automatization: are some professions really doomed?

A. *Description of the Phenomenon*

Job automatization, or *labor automation*, is the phenomenon in which human labor is replaced by a technological system, so that the latter carries out specific jobs or tasks the former was originally hired for. This process involves particularly "routine tasks" [1, p. 21], namely repetitive tasks characterized by high vertical[2] and horizontal[3] specialization. However, labor automation does not limit itself to these kinds of jobs, but also others with different specialization criteria are prone to a greater or lesser automation risk[4,5].
If we think of technology improving the manageability of tasks bestowed on humans, this has been happening since the invention of the wheel around 3500 BC. But modern automation, the one described in the paper, began during the Industrial Revolution. Factories and mass work turned out to be more productive than farmers, because steam machines could perform many tasks already done by farmers alone, but at a much faster pace than the latter could. Therefore, industrial machines replaced the experience of single farmers, who in greater and greater quantity left the countryside, in order to look for another opportunity in factories.
Whilst the phenomenon is rooted in two centuries ago, its extremely rapid speed has a much more recent origin, as shown in Fig. 1.

Aside this evolution in the power of machines, a number of factors do favor the rise of their usage in companies: (a) the efficiency of machines in performing repetitive tasks with respect to the human counterpart, (b) the enhanced user experience with customers, and (c) the economic revenue in avoiding human-related work risks.
If we focus on (b), that advantage is also related to the current phenomenon of consumerism: through visual stimulation customers constantly receive tailor-made advertisements of products they may want earlier than they would. [4] This hyper-personalization of advertisements [2] ensures a fact-based understanding of customers [3] and this apparently close relationship that customers feel with companies leads them to buy more often and trust these companies more, hence the aforementioned enhanced user experience.
(a) and (c) are connected with each other, because hiring a human worker entails some risks which they may encounter

[1]It is a wide branch of computer science concerned with building smart machines capable of performing tasks that typically require human intelligence. [62] Human intelligence in this case is regarded as a combination of different features: learning, reasoning, problem solving, perception, and using language. [63]

[2]Vertical specialization refers to the decision power attributed to the position of a person's job: if a job entails low vertical specialization, the person's duty is to mainly decide [the business's organization]; otherwise, they don't decide, but are limited to simply executing [tasks].

[3]Horizontal specialization refers to the number of different tasks assigned to a duty in order to reach a specific output: the lower the horizontal specialization of a person's job, the more tasks they are supposed to carry out.

[4]https://willrobotstakemyjob.com/top-paid-high-risk-jobs

[5]https://willrobotstakemyjob.com/lowest-paid-high-risk-jobs

[6]The moment in which "technological progress will become incomprehensibly rapid and complicated." (J. von Neumann) [16, p. 10]

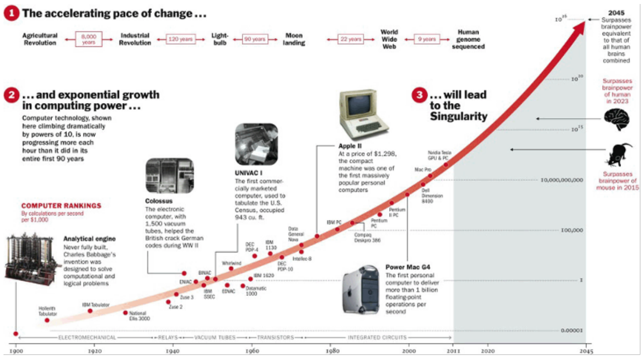

Fig. 1. Graph of the predicted exponential growth in computing power from the 20th century to 2045. On the x-axis time is indicated, on the y-axis the number of computations per second. The image is dated to 2011. It can be seen that the exponential plot starts reaching a considerable derivative within the period of integrated circuits (1970s – 2011) and it is estimated to reach the point of technological singularity[6] next year, in 2023.

in their job, such as potentially falling sick or injured. And that worker can guarantee only a certain degree of performance. Of course a machine is subject to a failure rate[7] as well, but the risks of sickness and injury are avoided and the machine can ensure a much higher throughput.

As a result, there appear to be two different scenarios for customers and workers in terms of consequences of job automatization: the former benefit from the enhancement of the services they can get, the latter are more affected by these consequences and their position may be subject to an uncertain future. The paper focuses on this very perspective of workers. These same consequences have led to the development of two opposite points of view[8] on labor automation in the literature: *AI augmentation theory* and *AI skepticism theory*.

B. AI Augmentation Theory

The first viewpoint proposes an optimistic interpretation of the consequences brought by job automatization. AI systems in the current state of the arts are perceived as **optimizers in the labor market**, as Kai-Fu Lee states[9], in the sense that they do not merely take over job fields, but rather help human workers enhance the quality of their due tasks. These systems cannot completely replace humans, because they are still far from emulating artificial *general* intelligence [5], the one characterizing our mental processes: machines lack features such as cross-domain knowledge, compassion, humor comprehension and self-awareness. However, they are actually replacing human labor in repetitive jobs – as mentioned in section I-A –, but at a much slower pace than suggested by media coverage[10], and this path does not only determine negative side effects: 85 million job positions will supposedly be displaced, but at the same time 97 million new ones will emerge due to an adaptation to the displacement shift [6, p. 29]. Furthermore, this displacement allows people to dedicate themselves to more rewarding job positions (see Fig. 2).

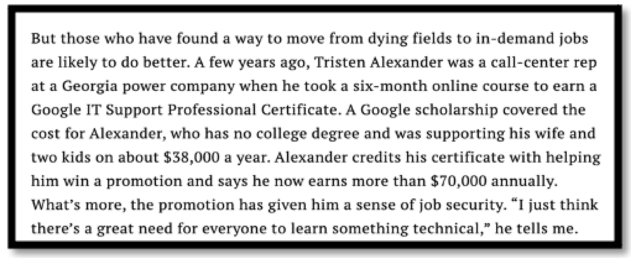
But those who have found a way to move from dying fields to in-demand jobs are likely to do better. A few years ago, Tristen Alexander was a call-center rep at a Georgia power company when he took a six-month online course to earn a Google IT Support Professional Certificate. A Google scholarship covered the cost for Alexander, who has no college degree and was supporting his wife and two kids on about $38,000 a year. Alexander credits his certificate with helping him win a promotion and says he now earns more than $70,000 annually. What's more, the promotion has given him a sense of job security. "I just think there's a great need for everyone to learn something technical," he tells me.

Fig. 2. Witness of a worker, Tristen Alexander, who took advantage of the job demand shift. Statement taken from [7].

New job positions are generated by a virtuous cycle: data are collected as fuel for the AI system, which consequently trains itself and improves; as the AI improves, the user base grows thanks to the enhanced user experience (see section I-A), the company makes more money, buys more machines and hires more employees to train them[8]. This has happened, for example, in the field of video games: as years passed, a higher and higher request of a more elaborated and structured graphic experience (in terms of design, physics and voice talents) has considerably increased the number of team members necessary for the development of a video game.

In this scenario *AI augmentation theory* strongly advocates for investing in education, in two particular terms: (a') retrain displaced workers, and (b') gain useful skills beforehand. (a') aims to reduce the effect of current job displacement through a new arisen industry of job reallocation firms [1, p. 789]. (b') suggests training basic skills like verbal and written communication, as machines are still not as capable of mastering them as humans; and also learn the basics of the necessary Math (calculus, algebraic linear regression, statistics) to understand the outputs of AI algorithms [5].

The next two issues are not strictly related to the influence of AI in the labor market, but highlight how in general people react to AI's more and more pervasive role in society, feelings which are more specifically reflected in the labor sector as well. Specific focus will be put on how *AI augmentation theory* responds to them.

1) The Issue of Technophobia: One significant issue *AI augmentation theory* addresses is a diffused feeling of "technophobia".

Technophobia refers to a set of negative sensations (in particular, anxiety) towards computers or computer-related technologies, their societal impact and the processes of interaction with them (Rosen and Mcguire, 1990) [16, p.10]. This mass anxiety has been observed to constantly appear in the last decades (Selwyn, 2000). One example is *The Triple Revolution* [17], a letter addressed to former President Lyndon B. Johnson, in which Ferry et al. expose their concern for the simultaneous

[7]The anticipated number of times an engineered system or component fails in a specified period of time (as such, it is expressed in units of time).

[8]Disclaimer: the names of the viewpoints quoted in the paper are not official names used by any source, but off-the-record titles given with the only purpose of highlighting a summary of the main ideas the two theories convey.

[9]https://www.youtube.com/watch?v=gX2DrPBQEpk&ab_channel=WorldEconomicForum

[10]This will be the subject of subsection I-B2.

occurrence of three different revolutions back then in the USA: cybernation, weaponry, human rights [17, p. 4]. The first of the three caused the greatest preoccupation to the authors of the letter: according to them, the US was on the brink of economic and social upheaval because industrial automation was going to put millions of people out of work. [6] Later in time, also great minds, like Stephen Hawking [18] and Elon Musk (see Fig. 3), have embraced a fearful position with respect to the potential impact of AI on our future.
The reason behind technophobia is a feeling of uncertainty due to the unanticipated, indirect and undesirable consequences new AI technologies might bring (Jalonen, 2011). Moreover, psychological studies (Newcomb, 1953; Osgood & Tannenbaum, 1955; Heider, 1958) have revealed an intrinsic desire of humans for psychological equilibrium, hence because of this unpredictability innovative[11] creations are either frowned upon or looked at with uncertainty because of the psychological imbalance that they bring as a change imposed on people. [16, p. 10–11]

Fig. 3. Public statement by Twitter user *CNBC* (CNBC) on Elon Musk's position on AI.[12]

2) The Issue With Media Coverage of AI: The aforementioned technophobia finds its main pervasive means of communication within media. Researchers (those believing in the optimistic view of *AI augmentation theory*) have been criticizing how some media write about new creations in the field of AI before the AI winter in the 1970s and after the major interest regain in the 2010s. One title associated to this kind of phenomenon is "AI misinformation epidemic" (Z. Lipton), referring to a widespread usage of an alarmist hyper-sensational tone by news organizations, whose aim is to create a clickbait, but reveals a shallow analysis of AI machines with exaggerated assumptions about their future. This issue stems from a number of reasons, such as: (a) low-quality training and integrity of journalists (Z. Lipton); (b) the uneven distribution of wages between an AI researcher and a journalist (J. McNeil), because a thorough detailed analysis of AI technologies is not worth the time and the much lower income of the latter; (c) cultural hopes and anxities (G. Bell), which also reflect the threat to the psychological equilibrium mentioned in subsection I-B1. [19]

C. AI Skepticism Theory

At the basis of this viewpoint lies a skeptical feeling towards the optimistic attitude presented in section I-B: according to this current of thought, AI augmentation theory proposes a reassuring, yet misguided perspective. The main point of *AI skepticism theory* is that AI will not only optimize jobs, but it will then replace the human workers originally hired for them. **AI as an optimizer is hence just the first phase of the paradigm shift**, because workflows, infrastructures and user preferences take more time to change. However, *the future perspective is uncanny and futilely sugared*: once an AI system fulfills the purpose of its creation[13], there is no practical or economic justification to keep involving humans in that field. The evolution of the influence of AI in the labor market has a similar trend to the idea of centaur chess (see Fig. 4): the first phase involves the current decade and can be called "centaur phase", as AI will augment human labor in this period, thus creating a sort of hybrid type of worker; the second phase, wherein the utility of human labor will be questioned, can be called "replacement phase". Fig. 5 shows an example of this progressive shift, in particular of the effect of the centaur phase, during these years.

Nevertheless, *AI augmentation theory* gets enormous credit, as it does not threaten the possibility for humans to keep this event under control and stay unchallenged on top of the cognitive food chain, without the need of any deep, uncomfortable reconceptualization of their position in the world. [8]

The skepticism behind this viewpoint finds its reasons within the envisaged consequences of job automatization on the social composition: ($\tilde{a}$) pain and dislocation from job loss across all social strata, geographies and industries, because many workers' skills will be out of demand and their roles obsolete; ($\tilde{b}$) there won't be enough meaningful jobs to employ every working-age person; ($\tilde{c}$) people won't be needed to generate the material wealth we're in need of – for instance, AI will allow us to synthetically generate by ourselves food, shelter and medicine at scale and at low cost – [8]; ($\tilde{d}$) reduction of wages because of a smaller (economic) value of human labor with respect to machine performance [9, p. 5].
In light of these potential consequences also *AI skepticism theory* advocates for a meaningful investment in retraining and

[11] *Innovation* is any idea, practice or object that people see as different. (Zaltman & Wallendorf, 1983)
[12] https://twitter.com/cnbc/status/983851881666699265
[13] Perform jobs more accurately, cheaply and efficiently than humans.

Fig. 4. Picture of centaur chess. The concept of centaur chess states that in a chess game the best AI player (in the world) will always beat the best human player, but a combination between the best AI and the best human player is the best chess player ever. The centaur mentioned in section I-C resembles this idea. *AI skepticism theory* claims that, given the current disparity between humans and AI systems, the performance of the best AI chess player is invariant to human intervention in the game, in the sense that AI is so powerful that the best AI player is the best chess player ever with or without the help of the human counterpart: one example of such advanced algorithms is DeepMind's *AlphaZero*, invented in 2017. [15]

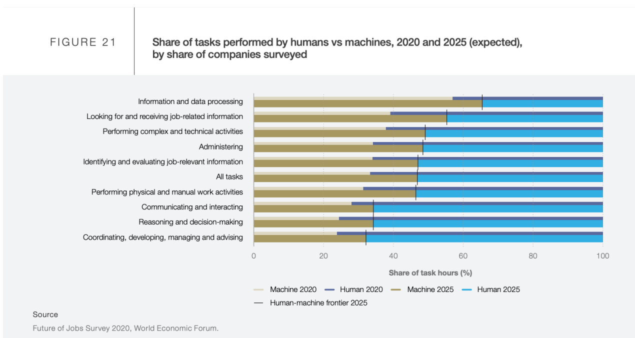

Fig. 5. Share of task hours spent by humans and machines in 2020 and expectedly in 2025. Figure taken from [6, p. 29].

reskilling by governments and private employers to postpone the obsolescence of human workers. Moreover, it stresses the importance of a paradigm shift in how society conceives of resource allocation: material goods and services will be cheaply available thanks to automation, but demand for compensated human labour will be scarce – this is strictly related to ($\tilde{c}$).

1) The Prospect of Rising Inequality: As already mentioned in section I-A, low-skill tasks are more prone to a higher risk of automation. However, studies (Frey, C. B. & Osborne, M. A., 2013) have shown a considerable risk for many kinds of jobs, posing a threat for the middle class too (see Fig. 6). Mainly roles requiring "human touch"[14] (K. F. Lee) will most likely survive. According to Stephen Hawking, AI will bring a massive boost in the efficiency of industries' supply chain, but the feared replacement of human labor will accelerate societal inequality, as very small groups of individuals benefit from the highly profitable application of AI systems and accordingly hire very few workers. [21] This situation can be described with the name of *Turing trap* [31, p. 3]: machines are used solely to "pass the Turing test", that is to trick the human counterpart into thinking they are dealing with a human interlocutor instead of a machine. In this context, machines are used to emulate human labor (by automating it) rather than augment it, and this mechanism risks to reach an equilibrium wherein people without power cannot improve their outcomes, having hence fallen into a trap, the Turing trap. However, this threatening prospect is not only dependent on the phenomenon of labor automation itself, but, states the economist Erik Brynjolfsson, it is also favored by the interests of three groups of people finding automation alluring: (a) technologists, who have been trying to replicate human intelligence in computers in order to find out what the latter cannot do with respect to us humans; (b) businesspeople, who see in plug-and-play automation[15] the simplest way to boost their production; and (c) policy-makers, whose initiatives have had the goal of automating human labor rather than augmenting it (e.g., the US tax code imposes higher effective taxes on labor than on plants and equipment [14, 32]). [31, p. 2–9]

Figure 95. Comparison of UK Skills Forecasts and Estimated Probabilities of Automation

SOC group (2 digit)	Probability of Computerisation	UK projected increase, 2012-2022 (000s)
Corporate managers and directors	15.8%	493
Other managers and proprietors	18.4%	93
Science, research, engineering and technology professionals	11.3%	354
Health professionals	2.1%	332
Teaching and educational professionals	4.3%	152
Business, media and public service professionals	21.3%	337
Science, engineering and technology associate professionals	52.5%	47
Health and social care associate professionals	17.9%	102
Protective service occupations	25.9%	-39
Culture, media and sports occupations	21.8%	88
Business and public service associate professionals	44.4%	384
Administrative occupations	80.4%	-159
Secretarial and related occupations	78.4%	-327
Skilled agricultural and related trades	70.8%	-41
Skilled metal, electrical and electronic trades	48.1%	-103
Skilled construction and building trades	52.7%	73
Textiles, printing and other skilled trades	57.5%	-236
Caring personal service occupations	44.4%	594
Leisure, travel and related personal service occupations	49.7%	55
Sales occupations	85.5%	-202
Customer service occupations	66.9%	138
Process, plant and machine operatives	84.4%	-211
Transport and mobile machine drivers and operatives	52.7%	-3
Elementary trades and related occupations	69.5%	-23
Elementary administration and service occupations	71.8%	-44

Source: UKCES (2014), Frey and Osborne (2013). Notes: 'Probability of Computerisation' is an employment weighted average of estimated probabilities at the SOC 4 digit level. The table is divided into SOC2010 major groups 1-3 and 4-9.

Fig. 6. Percentage of automation risk and projected increase (in thousands) between 2012 and 2022 of jobs belonging to 2-digit Standard Occupational Classification (SOC) groups. Figure taken from [22, p. 118].

This inequality also involves wages distribution, as quoted by ($\tilde{d}$). In general, digitization has not decreased the demand for low-skill workers [41]. Even though it has created new highly paid job positions, these have hardly arisen in the manual work realm and depend on constant economic growth. So what happened was a reduction of wages in OECD countries in relation to productivity between the 1980s and 2010. On the one hand, the demand for highly qualified workers is leading to rising wages in the high-wage sector; on the other hand,

[14]Compassion, empathy.

[15]Replace a human with a piece of machinery in every task.

work intensification and automation are increasing the wage pressure on medium- and low-skilled workers. [42, 33] Fig. 7 explores more in detail the probabilities of wage affection due to labor automation. Further details about wage inequality will be dealt with in section I-D.

Income Inequality Scenarios

Scenario	Gini coefficient	90-50 ratio	50-10 ratio
Pre automation	0.31	2.34	1.74
Post automation, become unemployed (Income = 0)	0.70	—	—
Post automation, earn minimum wage	0.43	5.58	1.00
Post automation, receive a 20% pay cut	0.35	2.67	1.80

SOURCE: OES, Frey and Osborne (2017), and authors' calculations.

Fig. 7. Income inequality possible scenarios because of automation. The Gini coefficient measures income inequality in a population: it varies between 0 (perfect equal income distribution within a population) and 1 (perfect unequal income distribution within a population, namely only one person detains the whole income). The 90-50 ratio is the ratio of the income of the 90th percentile to the 50th percentile, and the 50-10 ratio is of the 50th percentile to the 10th percentile. These ratios can have a value greater or equal to 1. Higher ratios indicate higher income inequality. The assumption behind the computations is that if an occupation has a 60 percent chance of automation, 60 percent of the employees get one of three hypothetical, alternative labor market outcomes after automation: (a) affected employees become unemployed and become zero income, (b) affected employees gain the minimum wage, (c) affected employees take a 20% pay cut on their previous wage. Table taken from [39]. These probabilities are not specific of any job field, nor have more specific automation risk probabilities per field been reported, but details on them can be found in [39].

D. *Case Study: The COVID-19 Pandemic*

Aside the generic discussion on labor automation and the two viewpoints, the paper now focuses on the case study of a present important event which, among its catastrophic effects, has also had an impact on the phenomenon under analysis: *the COVID-19 pandemic*.

Generally speaking, the pandemic has drastically accelerated job automatization, mainly for two reasons: (i) workplace infections had to be avoided, and (ii) operative costs had to be lowered due to activities being shut down. The everyday life radical shift also involved the way of working: on the supply side, automation has provided useful applications, such as disinfecting robotic systems, drones for product delivery and virtual networks to allow colleagues to communicate with each other during smart working (e.g., Microsoft Teams, Zoom); on the demand side, customers had to switch to digital channels to pursue their daily interactions and transactions because of imposed social distancing. The shift in the supply side resulted, among the various things, in a decline of the demand of low- and middle-skill jobs; the shift in the demand side in a potential preference of digitally enabled options by side of clients [10, p. 19].

Regarding the lack of preparedness, not only does it stem from the unprecedented speed of the Covid-19 pandemic outcomes leaving little time to adapt to a radical change of lifestyle habits, but it also lies in the flaws of the education system: labor automation through AI systems is no robot apocalypse, but rather "business as usual of people needing to get retraining, and they really can't get it in an accessible, efficient, well-informed, data-driven way." [7] This obstacle stems from a number of issues: (i) the amount of GDP [11] and federal money [12] spent by governments on retraining (see Fig. 8); (ii) college education focusing more on preparing new workers rather than retraining old ones, as it happens in the US [7]; (iii) many employers are still (logistically or economically) unable to retrain their teams [13]. Regarding (iii), Labor Unions are more likely to cover these expenses, but in 2021 only an average of 10,3% of American workers was represented by a Union [20, p. 12].

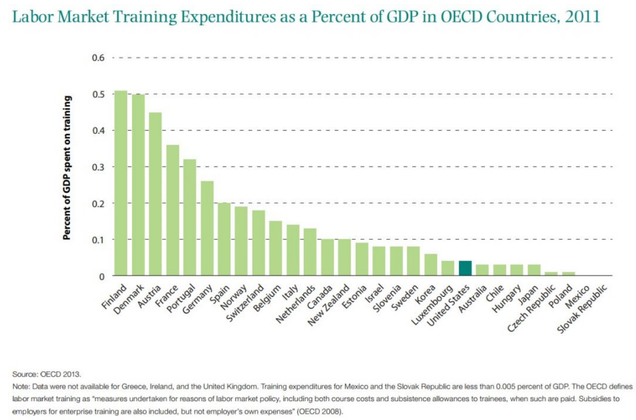

Fig. 8. Plot of the percentage of GDP spent by OECD countries on training workers in 2011. Figure taken from [11].

On the other hand, labor automation turned out to be an easy choice for many companies in crisis times: (a) the less the employees, the less income must be shared among them and the more with shareholders; (b) governments encourage companies to automate, by giving tax breaks for buying machinery and software [14]; (c) AI is becoming more adept to jobs that once were the purview of humans, making it harder for humans to stay ahead of machines (e.g., AI reviewing commercial-loan agreements, which completed in seconds a task that required 360.000 hours of lawyers' time).

Section I-C1 speaks about social inequality possibly related to labor automation. The outbreak of the Covid-19 pandemic has surely exarcebated these social differences, with particular disadvantage against those less financially stable and low-skill jobs. The cause is progress being biased against labor, with particular contribution from the current economic context: in a situation where economy was growing, workers would probably still be experiencing a slight increase in their wages despite a decline in the relative share of output they may earn; but Covid-19 has caused a drastic drop in the economic output across the world, thus creating a decline in that relative share of output, which implies that their incomes are falling faster than other economic sectors. Moreover, this inequality situation is further favored by the so-called "AI superstar" phenomenon: because digital technologies can be deployed at almost negligible cost, they can generate monopolies, market positions whereby superstar firms serve a large fraction of the market — either because of an undisputed superiority with respect to any other competitor, or because of a lack of attempts of competition against these superstars. It is the case of music industry: superstars have hundreds of millions of fans and share proportionate incomes between themselves, but further down the list these incomes drastically drop, so most of the rewards are collected among top performers. [40]

E. AI Revolution or AI Domination?

As we have discussed in the previous part, there are many ways to imagine a future dominated by AI technologies. In this part we want to explore the ways political interests play a role in the definition of these frames of futures defined by technological advancements.

1) AI Future Frames: AI futures frames are powerful in shaping discourse around AI technology. As defined by Entman, frames promote a certain aspect of reality that is then used to "promote a particular problem definition, causal interpretation, moral evaluation and/or treatment recommendation" [75, p. 52]. They emphasize certain aspects of a topic so a clear problem is formulated which favors certain solutions over others. If we take the discourse around "AI augmentation theory" and "AI scepticism theory" chronicled in sections I-B and I-C, respectively, we can see the effects of framing a topic in a certain way very clearly. According to Köstler and Ossewaarde [84] AI futures frames show a way to interpret uncertain information about AI technologies and they suggest certain actions. Furthermore, Köstler and Ossewaarde mention that a central narrative of these frames is that the "future is a more modern version of the past" [84, p. 252], without any changes in existing power structures. We can see this in the discussion around these two AI theories, both futures retell the narrative that AI will have a large impact on the way people work, either it will enhance a lot of people's work or it will replace them in their jobs. What lies unchallenged is the power employers have over the introduction of these technologies in the job market and that economic decisions will guide companies in the adoption of AI technologies. In these futures, the world will still revolve around maximizing profit. As Berendt notes: "Frames emphasize certain aspects of reality, and they suppress or even block others" [66, p. 53]. By focusing the discussion on the question of whether AI will be making human labor obsolete or not, we do not discuss other perspectives challenging the basic notion of structuring a large part of our society around the ability of a worker to sell their labor to employers. Instead we allow this framing to establish the technological deterministic idea that the coming advent of sophisticated AI technologies will impact our society in a profound and far-reaching way.

This narrative can then be used to legitimize certain political ideologies or solutions. In "Talking AI into Being", Bareis and Katzenbach [64] analyze AI strategy papers from the US, China, France and Germany. In these strategy papers the countries all show a clear framing in which they assign a certain problem to the concept of an artificial intelligence, which lends them to promote a specific judgement of this problem and finally allows them to present some necessary political solution. First they highlight the viewpoint of AI as "an inevitable technological pathway" [64, p. 864]. At the same time they emphasize that AI will cause a great upheaval of our way of life. As already described in Section I-C, this viewpoint assumes that the existence of a technology alone will cause great changes in a society. Bareis and Katzenbach criticise this way of thinking as technological deterministic, because it ignores historical continuities. Additionally, these strategy papers create an urgency by emphasizing the international competitive advantage these technologies are able to deliver. The American strategy paper paints the bleak picture of a defenseless country without any allies and unable to compete economically in the world stage, would they not adopt AI technologies [64, p. 868]. At the same time, Germany emphasizes that it has so far not been at the forefront of AI development, but if both the industry and the public work together this can yet be achieved [84, p. 255]. Moreover, the race to develop AI is portrayed as winner-takes-all. Would Germany not achieve this, the German welfare would be diminished [64]. Thus, as Bareis and Katzenbach [64, p. 869] put it, "the advancement of AI now seems vital as the resilience of an entire society depends on it". Framing AI technologies as powerful weapons in an international battle for leadership, domination and sovereignty, in which success determines the welfare of a people, allows political leaders to portray themselves as saviors, making unjust decisions justifiable [64]. In China AI technologies are promised to bring "social order and regulation" [64, p. 873], in France they are key to advancing humanity as a whole, in the US they empower the worker and American Industry [64, p. 872] and in Germany the focus is on creating ethical AI which at the same time makes the German industry a worldwide leader again [84].

2) Industrie 4.0: We see the same strategy of using framing to legitimize certain policies in the discussion around the *Industrie 4.0*. Industrie 4.0 is the vision of the German government to modernize the production industry in order to, among other things, improve resource usage efficiency and change the way we work [91]. At the same time, Industrie 4.0 abandons previously held visions of the future featuring fully automated factories and instead promotes a vision that is apparently human-centered [77, 91]. Central to the discourse around Industrie 4.0 is the need to increase the advantage of the German industry [77]. "All other needs and interests have to adapt to this central demand" [77, p. 103].

Industrie 4.0 debates focus on building global production networks forming "Cyber-Physical Systems", where humans and machines work in a self-regulating way in production facilities that are networked worldwide to other facilities [91]. The goal is, according to Pfeiffer, to "create structures free from local connections, regional expertise, and labor market-specific configurations" [91, p. 116]. While much talk around the vision of Industrie 4.0 focuses on empowering human workers, highlighting more self-direction as an increase in decision making opportunities, Pfeiffer [91, 90] asks how this is going to increase their autonomy if they are entangled in a global production system, that self-directs itself optimally to maximize efficiency and profit.

This next section gives an overview of the consequences for workers worldwide when cybernetic ideas of work regulation are introduced in companies to increase their economic returns, and hopefully it will answer the question Pfeiffer asks in the last section of "The Vision of "Industrie 4.0" in the Making—a Case of Future Told, Tamed, and Traded": "Is this digitally augmented hollowing-out of both the private sphere and of labor rights and the democratic potential of industrial relations not a new form of despotism?" [91, p. 119].

II. Cybernetic Proletarianization: The Degradation of Work Through Algorithmic Control

Referencing Bravermans work "Labor and Monopoly Capital: The Degradation of Work in the Twentieth Century" [70], this section discusses the degradation of work through an increase in algorithmic control and how this process furthers the precarization of a large amount of laborers. First we discuss what regulation of work is, then we give an overview of scientific management as a historical means to regulate work, followed by a definition of cybernetic regulation of work. Lastly we discuss the concept of cybernetic proletarianization and the effects of cybernetic regulation of work on working people.

A. *Regulation of Work*

Regulation of work is needed to control the way labor is used in production and service based economies. While a work contract already specifies broad circumstances of the way work will be done, continuous interventions have to be performed by the management of a company to effectively direct the way work is executed [92]. Marx [88] described the need for control of the labor process from the view of the capitalist as making sure that the means of production are utilized adequately and that no raw material is wasted.

According to Black regulation can be understood as "the sustained and focused attempt to alter the behaviour of others according to defined standards or purposes with the intention of producing a broadly identified outcome" [68, p. 25]. Giving a more specific definition, Eyert, Irgmaier, and Ulbricht [76] have identified five dimensions of regulation: (1) intentional actions, (2) through direct or indirect interventions, (3) by both state and private actors, (4) encompassing all kinds of activities (5) that can also act on the regulating body itself (self-regulation).

Different modes of work regulation happen along these five dimensions, and there might be multiple regulatory interventions counteracting each other.

B. *Scientific Management*

Scientific management (or taylorism) was a way to organize work developed by Frederick Winslow Taylor in the early twentieth century. Taylorism featured a great amount of tight, regulatory control over work processes. Because Taylor believed that a workers natural tendency is to do as little as possible, he developed a model of regulation that featured little decision making processes by the working person and instead relied on them following precise, detailed instructions [86].

Scientific management affected work in three ways [86]. (1) It changed the work that is done through division of labor, tasks that used to be done by one person were now split into multiple steps and done by multiple people. (2) It changed how the work is done through control over the way tasks are executed, the methods of scientific management allowed much more control over the labor process. (3) It changed the relationship between the worker and the employer, the formalization of a lot of knowledge over the work process began, employers gained a lot of control over the relationship between them and their employees.

To introduce the methods of scientific management into the workplace, first a systematic analysis of the work had to be done. Taylor proposed to invent a "science of work" [86]. The goal was to find the "one-best-way" to do a task. To achieve this, proponents of scientific management used a wide array of observational techniques to document task execution. Workers were timed using stopwatches, they were filmed and photos were taken. Frank Gilbreth connected lights to different parts of the body of a worker and then took long-exposure photographs which allowed him to retrace the exact motions that were used to finish a task [93]. Workers had to try to work with different layouts of their workstations, they had to try different motions or body postures until the best way was found [86]. According to Braverman [70], this furthered Taylors purpose of cheapening and deskilling the workers. Braverman furthermore chronicles different excerpts from Taylors works, in which he argues that it is always in the interest of the worker to keep their knowledge of their work to themselves, so that they retain their competitive advantage. He thus had to develop the methods of scientific management to force workers to give up their retained knowledge over work processes.

These findings then allowed managers to change the way work was done. Because the methods of scientific management allowed management to consolidate the knowledge of execution of work tasks, they now also had the power to direct this execution [70]. This was done through standardization, the development of explicit, unified work practices [86], with Littler [86] calling this a "historical shift" in power over the labor process. According to Braverman [70, p. 82] this made possible the "use of this monopoly over knowledge to control each step of the labor process and its mode of execution". Taylor achieved this through a decomposition of work tasks into smaller atomized subtasks. He then proposed a split in planning and executing work, a middle management would plan the whole work process ahead and a worker would simply execute these plans [86]. Since standardization allowed a greater understanding of the work processes to the management, this also meant that it was now easier to observe laborers in their work performance and to correct them if they deviated from the intended way of execution [70].

The introduction of Taylors methods then changed the relationship between the worker and the employer. Because knowledge of work processes was now consolidated by management, the dynamic between workers and employers changed. Hoxie described these developments as depriving workers and craftsmen of their unique skill. Workers become nothing more than an “animated tool of the management” [82, p. 132]. Scientific management methods thus allowed lower requirements for certain jobs and also faster job-trainings, which allowed the employer to excert a greater influence over their workers [86]. While taylorism and scientific management as terms fell out of fashion in popular perception, the mode of regulation of work has stayed and even intensified with the introduction of digital technologies as the following sections will show.

C. Cybernetic Regulation of Work

Cybernetic concepts have been developed in part based on findings in biology pertaining to homeostatic systems. They are systems containing some form of a feedback loop that acts according to some defined goal state. According to Carver and Scheier [72], there are four important aspects of cybernetic feedback loops: (1) an input, (2) a reference, (3) a comparison and (4) an output . If the goal of such a loop is to create a *homeostasis*, which is the case if some goal state is reached, then the feedback loop might measure the current state, compare it to the goal state and direct the output to reduce the discrepancy between these two states. These kinds of loops are also called discrepancy-reducing feedback loops and they will be the focus of this work. There are also discrepancy-enlarging feedback loops which act to increase the discrepancy to some reference state.

Jochum explains in “Kybernetisierung von Arbeit - zur Neuformierung der Arbeitssteuerung” (“Cybernetization of Work - Reshaping Work Regulation”) how cybernetic ideas of control took over from earlier taylorist and machinist ideas of human labor. Labor was at first conceptualized according to a machinist model, human labor has to be utilized for the most value as with machines [83]. Thinking and executing work is separated and human behavior is restricted as much as possible to decrease any variances and to maximize productivity of the worker. Decomposition of work steps furthers this by decreasing the amount of motions a worker has to execute and by greatly monotonizing their work. Later these ideas lost importance with production steps getting automated and workers having more specialized knowledge which changed their work to project and group based models where the ideas of scientific management could not come to fruition [89]. Taylorist models of control worked well by greatly constraining work and removing as much variance in task execution as possible. This, however, proved inadequate to function in these changed work settings characterized by dynamically evolving objectives. What followed was a “subjectification of work”, which describes a change from traditional models of direct control to jobs requiring self-regulation and self-direction of workers [80].

Regulation of work moved to more decentralized and individualized modes of control, requiring permanent self-reflection of its subjects [83]. This coincided with the development of the “cybernetic self”: workers that are capable of using cybernetic ideas of self-optimization to regulate themselves in a changed landscape of work characterized by more and more flexible working conditions. Both service based workers and workers in production industries had to assume much more autonomy over their labor process [80]. Flexibilization of working conditions changed the way the work is done but also brought changes to the environment or context in which work is done, for example by increasing the variance of working hours with the emergence of shift work. Günter Voß [80] extends this by calling this processes *Entgrenzung*, which describes a dissolution of organizational structures to save costs. This was possible because of the emergence of the subjectification of work. However, with objectives still being dictated from the outside, this increase in autonomy is restricted to individuals being left to their selves in how to direct their energy to attain these goals [83].

An early example of cybernetic regulation in the economies of industrial production can be seen at the car manufacturing company Toyota. A system was developed, based on paper cards, where production and control were unified in one information model called *Kanban* [92, p. 234]. With this system flexibilization already played a role too, having workers perform quality control themselves.

There are different ways cybernetic regulation can be exercised when acting on human behavior. Black [68] discusses cybernetic regulation as a form of social control, Hood, Rothstein, and Baldwin list three important functions a regulating system has to have: “standard setting, information gathering and behaviour modification” [81, p. 23].

1) Algorithmic Regulation of Work: Lee et al. [85] have described algorithmic management as software that assumes managerial tasks. In their extended framework for algorithmic regulation, Eyert, Irgmaier, and Ulbricht [76] argue to extend the framework by Hood, Rothstein, and Baldwin by changing the functions into ‘direction’, ‘representation’ and ‘intervention’ [76, pp. 27–28]. This reflects a change in cybernetic regulation that is enabled through algorithmically controlled computer systems.

Direction encompasses elements of systems determining goal states and the realization of these states. This is a departure from the dimension of standard setting because computers are able to change their goals based on changed environments, smart devices can adjust their optimization functions as needed and thus algorithmic regulation does not just deal with fixed goal states but also dynamically computed ones.

Representation describes not only the gathering of data but also the need for internal models concerning the representation of this data and the inclusion of premises about which data is gathered. Algorithms are programmed with specific needs and only consider information based on certain data models and available sensors. At the same time data is not just gathered from unambiguous sources but formed and framed by social circumstances. Eyert, Irgmaier, and Ulbricht argue that "representing involves an epistemic construction based on information or data, as well as their interpretation" [76, p. 29]

Lastly intervention emphasises that behaviors are not just modified, as Hood, Rothstein, and Baldwin may suggest, but that the subjects of these interventions might also have goals and behavioral tendencies that may lie outside of the possibilities of the regulator. This is reflected in the ways behavior can be modified, according to Eyert, Irgmaier, and Ulbricht. One way is through incorporation, which is "changing or creating properties of the regulated entity" [76, p. 33]. In cybernetic control this is achieved through subjectification. Another way is through excorporation, the changing of environments of the regulated subjects. Because algorithmic regulation of work acts through computer systems, these systems can be changed to include specific affordances causing certain desireable behaviors in the individuals using them. The Berlin Script Collective differentiates three kinds of excorporation: coercion, inducement and initiation of re-interpretation. Coercion is the threat of harm or force, computer systems may engage locks which "physically prevent customers without a ticket from traveling" [67, p. 11]. Inducement is the promise of rewards or the threat of removal of rewards. For example an algorithm may reward users that often log into an app. Initiation of re-interpretation describes is a triggering of a re-evaluation of a situation without changing the situation itself. This may be as simple as a sign "telling people not to swim in a river because it is infested with crocodiles" [67, p. 12].

Eyert, Irgmaier, and Ulbricht apply their framework to discuss algorithmic regulation of Uber drivers [76, pp. 35–36]. Considering the dimension of direction, it is clear that Uber as a for-profit company has the goal to maximize their profits. This goal can be split into subgoals pertaining to achieving a pleasurable riding experience for the customer while charging a fare that is as large as possible. The authors mention that these standards may be highly variable, with Uber constantly reevaluating how to measure the pleasure of a ride. Uber also sets external standards such as a star rating acting as a measure to get riders to improve the quality of their rides while threatening to remove access to the platform if they receive a rating that is too low. In representation Eyert, Irgmaier, and Ulbricht discuss different measures that are collected by the company, such as location data or driving data and also traffic data. This data is then fed into complicated data models deciding aspects like which driver gets to pick up a fare or which route should be taken. Discussing intervention, the authors mention no examples involving incorporation but they list examples for excorporation. Coercion happens when drivers lose access to the platform because their rating is too low or they display other undesirable behaviors. Inducement happens through certain monetary incentives, namely surge pricing which is an increase in fare prices for areas with a high demand in rides that incentivises drivers to focus more on a certain location in order to be able to quickly pick up new passengers. Initiation of re-interpretation is achieved through display of certain information like selected routes a driver should take to drop off their passenger.

Nachtwey and Staab [89] analyse the emergence of algorithmic regulation at Amazon. Pickers at Amazon warehouses use handheld scanners to orient themselves in warehouses. The scanners also direct workers to the shortest way and measure their time. Scanners allow the company to regain control over the work processes that has been lost because taylorist control was not applicable anymore. Pickers display a high variety of motions and tasks they have to execute, highly constraining them and decomposing their tasks into subtasks does not make sense. Algorithmic systems however, allow a reemergence of tight control and direction through the use of machines.

D. *Cybernetic Proletarianization*

Cybernetic proletarianization is an extension of the concept of cybernetic regulation of work by emphasising not just feedback loops affecting workers in labor contexts but also showing how feedback based effects affect them on a broader sense leading to an expulsion from their places of work [33]. Schaupp identifies the central element defining the term *proletariat* as people that are dependent on receiving wages, so called "wage dependency" [33, p. 14]. This includes both employed and unemployed humans. *Proletarianization* is described as a process involving two factors: formal subordination, which is "the eradication of other forms of subsistence beyond wage labour" and real subordination, which describes the "substitution of the skills and subsequently the automation of living labour in industrialization" [33, p. 14, 88]. While historically the proletariat was seen in terms of industrial production, the advent of algorithmic regulation of work enabled a digital taylorism in service based industries too [89]. According to Brown et al. [71] this facilitated a new process of standardization in the service industries. Today, effects of cybernetic proletarianization can be seen in almost all sectors of the economy. The increase in digitization across productive and service-based industries enabled the introduction of algorithmic control systems furthering a flexibilization and subjectification of jobs. Schaupp [33] marks three ways through which cybernetic systems further proletarianization, deskilling, intensification and automation.

1) Deskilling: Deskilling is the process by which qualifications are taken away from workers and formalized in machines. Braverman [70] already described deskilling in taylorism, where both machines and a middle management would assume decision making tasks that previously were part of the job of the worker. This allowed a tighter control over the work process and a shift of power away from the worker over to the company. Algorithmic systems allow new ways of deskilling. Cybernetic feedback loops make it possible to excert tight control over the labor process even in highly variable environments.

Eyert, Irgmaier, and Ulbricht [76] have looked at algorithmic control at Uber, where drivers are given a route and given passengers to take along that route, Nachtwey and Staab [89] discussed algorithmic control in Amazon warehouses where pickers are directed via handheld scanners and Schaupp [33] chronicled experiences of workers for a food delivery company where an app tells the workers how and when to work. In all these cases, algorithmic systems take over decision making aspects of jobs and replace them with computer generated instructions. This removes a lot of qualifications laborers need to work in a certain job which makes them much more replaceable. This replaceability works in the interest of the companies introducing cybernetic systems. In an interview carried out by Schaupp, the manager of a company argues that deskilling allows them to employ "less qualified and therefore cheaper workers" [33, p. 17], while others argue that they want to achieve a job environment where there are basically no qualifications needed. At the same time this allows companies to also greatly reduce the time to train people for a job. Thus, companies to quickly hire people when they are needed and let them go once they are not anymore.

Nachtwey and Staab [89] describe the emergence of "digital contingency workers" as one effect of this process. These are formally self-employed workers that have to supply their labor on-demand. Companies utilizing contingency workers have the freedom of not having to enter into an contractual agreement with the worker guaranteeing a certain fixed amount of paid work. Uber drivers are an example for contingency workers. While on the outside contingency workers enjoy a lot of autonomy over their work, practically they are in a "doubly contingent" relationship: they are dependent on matching the supply of their own labor power with the demand of the companies they are selling it to, while at the same time having no real influence on their wages [89, p. 14].

Schaupp describes this whole process as deskilled flexibilization, skills of workers are absorbed into machines which then allows employers to utilize the labor force much more flexibly [33, p. 18]. Furthermore this marks a "qualitative and quantitative expulsion of living labour from the production process" [33, p. 18]. Working knowledge is appropriated by the company and used at will.

2) Intensification: Besides deskilling, cybernetic systems also change the work environment through intensification. As described by Eyert, Irgmaier, and Ulbricht [76], interventions are one part of algorithmic regulatory systems. Schaupp [33] describes different kinds of interventions that are given by these systems. Some systems collect data to create performance profiles which are then used to judge whether employment contracts will be extended, others measure the speed of task execution of workers and generate automated feedback it is too low and one system measured the utilization of the workers productivity and automatically administered additional tasks if it was below a certain threshold [33, 87]. While intensification happened under taylorism already, through control of a middle management, the possibility of generating highly personalized, immediate feedback for each worker individually, often created from large amounts of data that is gathered for each individual separately, marks a change in control enabled through cybernetic systems [33]. Relying on the subjectification of work, these feedbacks then require self-regulation of workers to fulfill the given requirements.

This results in a great intensification of work. As discussed, control is exercised to increase work output and eliminate time not spent working. Scheiber [95] reports that cybernetic control systems at Amazon warehouses have raised the average pickers productivity by two to three-hundred percent. At the same time the workers there report work becoming more repetitive with no pauses or time to talk to coworkers except for their breaks. In interviews with workers, Schaupp [33] reports feelings of stress and disengagement or depersonalization. Workers have no agency and are told all day what to do next by computer instructions. This does not go unnoticed to employers, however, in another interview the manager of one company reported that workers are going to be somewhat of a "slave to the machine" which they would have to learn to deal with [87, p. 203].

Raffetseder, Schaupp, and Staab [92] discuss intensification applied through the management software Salesforce. There are multiple ways this is done, the software compares employees using performance indicators that it then presents in a dashboard to increase competitive drive between employees. Furthermore, it presents individual feedbacks by reporting if certain goals were achieved or not and it automatically assigns tasks to workers that are currently underutilized. They argue that this process is ultimately used to try to tether self-regulation processes of the workers to the goals of the company [92, p. 244].

Another effect of work intensification is achieved through the perceived consequences of deskilling. Workers become more replaceable, which has a disciplining effect on them [87]. This intensifies the pressure to give into self-regulating expectations so as not to be replaced.

3) Automation: Section I extensively discussed different scenarios of job automation and their potential effects on the workplace. It is important to note how cybernetic systems figure into automation tendencies. One kind of automation that is notable is the automation of the middle management created under taylorism. Because there is an increase in the subjectification of work, workers are pushed to exercise more and more self-control. This removes the need for a controlling instance of middle managers. Similarly with the rise of digital contingency workers, software is used to regulate their work remotely in a way a middle manager could not. Middle managers were also responsible for the appropriation of working knowledge, which computers now mostly take over [33]. This effect is already clear in the previously mentioned definition given by Lee et al. [85, p. 1603] defining algorithmic management as "software algorithms that assume managerial functions".

Schaupp also emphasises an increase of data-based automation through cybernetic systems of control: "digital tracking serves to control the labour process, but also to automate it" [33, p. 20]. Data is gathered during work processes and then used to automate these processes. For example, in one company warehouse transport robots were automated using data gathered from workers there [33, p. 20]. At the same time Uber says that they are trying to create self-driving cars, making human drivers superfluous [94, p. 134]. Yet while companies like Uber or Amazon have announced to automate a large part of their work processes these automation tendencies are not yet observable [94]. This is in part, Schaupp argues, because of their technological deterministic view. Just because things can be automated it doesn't mean they will. Often economic factors play the deciding role in companies deciding whether to invest in automation or not. In an interview the manager of one company explained that because of the effects of deskilling, labor has become so cheap that it is more cost efficient to hire human workers than to invest in automation [33, pp. 18-19]. There is even the case of some companies employing human workers disguised as AI chatbots or others using clickworkers to transcribe receipts uploaded to a software while advertising a "smart scan technology" to their users [96]. In other cases working councils were hoping to automate some parts of jobs dangerous to the health of the workers but these wishes were dismissed because they would not increase the productivity of the worker [94, pp. 132–133]. However as discussed in section I-D and as Schaupp [94] notes, the Covid-19 pandemic has made it economically rational for some companies to begin the automation of some work processes.

In general it should be noted that while automation might replace some jobs, the problem is not the unavailability of work to the worker but the degradation of work itself. Even considering recent effects like the Covid-19 pandemic or the economic effects coinciding with the Russian invasion of the Ukraine the German job market is still prognosed to grow [78]. While some jobs get automated, new jobs are created at the same time featuring worse working conditions. Martin et al. [87] contrast a decrease of unemployment in the German labor market with a concurrent reduction of work hours. This can attributed to an increase in flexibilization of work which allows companies to greatly optimize their usage of work hours but causes an intensification of work on the side of the employee. While Uber might be able to just pay their drivers when rides are actually needed, Uber drivers have to adjust their work schedules to times where rides might be requested, greatly constraining their time while at the same time increasing monetary uncertainty.

4) Degradation and Precarization of Work: The effects of deskilling, intensification and automation of work can finally be judged by looking at their impact on the way work changes, notably how the proletariat is increasingly precarized.

Dörre [73, p. 252] explains precarization as a working condition that is characterized by laborers living at a level of income, protection and integration that is deemed much below what is considered the standard in a society. Furthermore precarized workers experience a personal loss of sense or participation in their work [87]. These working conditions are also defined by an uncertainty which reduces a workers ability to plan for the future, workers living in precarious conditions are the first to be fired [73, pp. 253–254].

Nachtwey and Staab [89] discuss the digital contingency worker as a new kind of worker working under conditions characterized by precarization. Notably, they live under uncertain working conditions, only getting paid if they are actually needed. The previously discussed processes of an increased deskilling of work furthers this. Fewer required qualifications and shorter training times means contingency workers can be hired dynamically and once they are not needed anymore the work relationship can be ended easily. For example, at Amazon there are times where there are more seasonal workers working in the warehouses than regular employees [89, p. 6]. Computer systems also allow employers to include an increasing number of people into the pool of the dynamically accessible workforce. Schaupp [94] mentions that migrant workers are a central target group for this, who thanks to computerized control technologies, can be integrated more easily through onboarding systems that allow a selection of languages or use pictorial instructions. Brown et al. [71, p. 137] cite two car manufacturers explaining that in the last twenty years global production capacities changed so rapidly which means they can produce their cars anywhere in the world, with one manufacturer emphasizing that they can pay their employees in other countries much less than in the US or Europe. Dyer-Witheford [74] uses the term "cybernetic vortex" to describe this growing tendency of, on the one hand "making labor available to capital on a planetary scale" [74, p. 15], while at the same time expelling large amounts of superfluous workers.

There are two general hypothesis on how an increase in algorithmic regulation of work change the nature of jobs. The theory of "hoarding of opportunities" suggests that the effect of an increase in algorithmic control of work depends on already existing inequalities in autonomy [79, p. 520]. People with high amounts of autonomy in their jobs do work that is harder to regulate and they have a better bargaining power over their work conditions. In effect, algorithmic systems simply substitute a human management without changing existing relations of autonomy. In contrast the "polarization scenario" suggests a fundamental rift in in work autonomy between high-skilled and low-skilled workers with workers who are medium-skilled experiencing a significant change in work quality [79, p. 522]. Gensler and Abendroth [79] find evidence that an increase in the usage of algorithmic control systems in work environment causes an increased inequality of work autonomy between jobs with a higher or lower status. Workers that are presented with computer generated instructions often report no way of challenging these instructions to retain their autonomy. Furthering this experience of a loss of autonomy workers also report a lack of traceability of instructions. Lee et al. [85] interviewed drivers for ride-sharing apps who reported a desire for more transparency on how passenger assignments are generated.

All these effects further the precarization of a growing amount of workers. Schaupp [94, p. 256] expands on the concept of the "cybernetic vortex" by differentiating between quantitative and qualitative expulsion. Quantitative expulsion is describes a reduction of employees, realized through automation or the intensification of work, less people can output the same amount of productivity. Qualitative expulsion is realized through deskilling, knowledge is shifted from the worker to the machine. Additionally Schaupp [94] notices that an expulsion does not necessarily result in a large, unemployed workforce. As mentioned previously, the ability to introduce algorithmic control systems into job environment allows a deskilling of these jobs which successively means people can be hired for much lower wages. This means that a lot of jobs are not replaced by robots but done by cheaply hired, precarious workers. Moreover some sectors of the economy are even reliant on a large, low-skilled or unskilled workforce that is ready to be hired when needed [94, p. 257]. Benanav [65, p. 123] recounts that "In countries such as the US, UK and Germany, few workers remain visibly and countably unemployed for long. Instead, they are typically obliged to join new labour-market entrants in jobs that are part-time, temporary or otherwise precarious".

The growing precarization of the workforce does not just affect those workers that are already working in precarious conditions but also those that are not. Martin et al. [87] mention that fears of devaluation can also result in precarization. Dörre [73] explains that the precarization of one part of the workforce in a company can act in a disciplining way on the rest of the workforce. Part-time workers often work in similar jobs close to full-time employees. Realizing that the part-time employees produce the same amount of work as the full-time employees can result in fears of replacement for the latter, which as Dörre writes, even causes workers to give in to bigger concessions in wage and work-time negotiations. Dörre cites Bourdieu by saying that the workforce is split into those who have a stable working status and want to keep it and those who are ready to do anything to escape their insecure situation [73, p. 253, 69].

Concluding, it can be said that the increase of cybernetic systems of algorithmic regulation of work has resulted in an increase of control over the execution of work which results in a decrease in the autonomy workers experience. Processes like deskilling, intensification and automation further the precarization of a large amount of workers which in turn also activates tendencies of precarization of workers in more stable work situations. In the end this enables employers to assume more and more power over the work environment while causing a successive degradation of work and life for most of working class people.

E. Cybernetic Proletarianization within Labor Automation

Section I has dealt with a black-or-white perspective of labor automation, in the sense that the phenomenon either lets a worker keep their job and enhance its quality, or kicks them out. Cybernetic proletarianization provides a grey area wherein most cases of job displacement actually occur: it involves a belittling of the perception of jobs, in other words employers introduce new intelligent systems to guide and control their employees' jobs, rather than to replace them. In this way, workers feel demeaned by the lack of that satisfiability this new perspective is unable to offer.

1) Data-based Automation: The Connecting Point: By quoting [34], Schaupp in [33] already pinpoints that job destruction via automation has received excessive credit in the discussion of the effects digitalization has on the labor market, because automation per se has played a minor role in the whole picture. However, one form of automation has actually advanced and, to some extent, contributed to the dynamics of labor automation on the whole: *data-based automation*.
As already mentioned in II-D3, data-based automation consists of the automation of processes which are based on the prior collection of data on human workers. In other words, what is automatized are processes wherein data and performance indicators of employees are collected and used to keep track of how these employees are carrying out a task and how they could do better. This specific type of automation contributes to labor automation by using the summoned data to feed new AI systems that will eventually replace those workers in the future. One example is the company *Uber*, which has been collecting data to control the actions of its drivers and also to make them a basis for the development of an AI for autonomous transport vehicles so as to fully substitute those drivers in the future. [33, p. 20]
Data-based automation is also related to the concept of alienation in wage labor explained by Marx in [35, p. 22]: when a worker spends themselves so much, they put their life into the object they produce, hence letting it become an external existence, alien to them, which strips them of that life they have given to it. In this context, a worker spends themselves because the employer (or "capitalist", using Marx's words) takes possession of the result of their production. Therefore, production contributes to the wealth and power of the employer, who "takes the object the worker has put their life in", and to the poverty and the powerlessness of the employee, "deprived of their life", thus creating the feared inequality risk mentioned in section I-C1. Furthermore, as it happened in the aforementioned example of *Uber*, as a (partial) result of the job of these affected workers, they produce data used afterwards to displace them from the production process itself, so these data are used both as a further layer of labor valorization, but also as a preparation for the definite shift [33, p. 20–21], which is the main claim of section I-C.

2) Convenience in Replacing a Human Worker: Section I-C claims that the undeniable disparity in performance between humans and machines will result in a sure replacement of the former in the longer run. This is also suggested by the previous subsection because of the active contribution of the digital proletariat in producing those data that will contribute to the displacement of human workers. But, despite all these considerations, the opposite question should be risen as well: is it always convenient to replace human labor?
One of the consequences of deskilling in cybernetic proletarianization is the potential optimization of production through a lower need of permanent workforce and a higher convenience of a flexible integration of temporary labor. In other words, production could be optimized in some cases by hiring people only when needed rather than in a more permanent position.

This possibility for flexible integration conveniently works out well for situations in which the machine encounters a setback and either its workload must be temporarily carried out by an available human worker, or that worker is hired to fix the machine. A practical example of this situation is given in [36]: in 2018, a hamburger-flipping robot named "Flippy" turned out to be unable to follow customers' orders and, as a result, the restaurant intervened and suddenly replaced it with human cooks, while it was being repaired. Such an event can happen, because even machines are susceptible to malfunctioning and, if an important part of the supply chain relies on them, it is essential to plug holes in that case.

Convenience in keeping human labor also relies on another key concept: *comparative advantage*, namely an economy's ability to produce a particular good or service at a lower opportunity cost than its trading partners. In the context of automating jobs, machines are more likely to be deployed in working environments where they would have the greatest *relative productivity advantage*, whilst humans where they have the smallest disadvantage. For instance, if robots can produce 10 times as many automobiles per day as a team of humans, but only twice as many houses, it makes sense to have the robots specialize and focus full-time where they're relatively most efficient, in order to maximize output. Therefore, even though people are a bit worse than robots at building houses, that job still falls to humans. [37]

On the one hand, comparative advantage leads to dismissing the idea of a complete shift in the labor market, as already proposed by section I-B. On the other hand, it must also be taken into account that from displacement due to globalization and increasing international trade, there is nothing that guarantees that humans displaced from jobs will be reemployed in new jobs that pay as much as their old jobs, or even pay enough to maintain middle-class status, as said in section I-C.

3) An Historical Insight of how Cybernetics[16] *Disrupted the Original Proletarian Class:* Aside with being deployed in the four stages of algorithmic work control, hence determining the aforementioned conditions current digital proletariat undergoes, new technologies have already been used to disrupt the structure of the former proletarian class since the 1970s, as thoroughly explained by Dyer-Witherford in [38]. At that time, the advancement of capital was threatened by a crisis in the class relations because of the strike power of the industrial working class which drove wage and welfare gains. The aim of the "cybernetic offensive" (N. Dyer-Witherford, 2016) against that powerful working class was to break down the strength of the latter, and that offensive happened by means of: (a) *automating factories*, namely the introduction of self-guiding tools involved in mechanical labor; (b) *relocation of industrial production* at a global scale at the lowest wage, and with maximum disposability, and minimum environmental regulation [43, 44, 45, 46]; (c) *new forms of commodification*, that is the interest in new forms of products (e.g., social media, consumer computing, etc.); (d) *financialization*, which involved the electronic connection of banks and stock markets [44, 47], and the development of increasingly esoteric financial instruments such as derivatives and futures. The result of these processes was a new class, a global proletariat, or better a set of global proletariats diffused and dispersed along the supply chains that gave capital a worldwide supply of labor.

[16]*Cybernetics* is used as a synonym of labor automation in the sense of introduction of new technological systems in (a specific sector of) the labor market.

Dyer-Witherford identifies seven main points proving the importance of the role cybernetics has played on the process of global proletarianization:

- **The erosion of global peasantry.** Due to the collapse of subsistence farming [48] by means of the introduction of automated harvesters and GMO seeds in the global food industry, many people fled from the countryside in an enormous new round of the primitive accumulation that provided capital's early proletariat. More and more people depend on commodity exchange, but only some can sell their own labor power, that is the only commodity they have;
- **New factory proletariats.** The aforementioned *relocation of industrial production* in old industrial countries like China has generated new industrial proletarian groups which not only are at the lowest rank of the supply chain, but also produce cybernetic machines. These groups are similar to the old concept of proletarian class, but share a solidarity feeling which, with respect to the one of the old proletarian class, is threatened by the capacity of new automation commodities to replace them, if malcontent on low wages is expressed;
- **Tertiarization.** Alongside the decline of agricultural work and the steadiness of the industrial one, the third sector (services) is growing instead;
- **Migrations.** The current state of migration because of cybernetization is characterized by a greater mobility of capital than people with respect to the first decade of the 20$^{\text{th}}$ century, but also by a greater migration wave in off-the-land routes within national borders (e.g., China);
- **Re-proletarianized professionals.** Informal work, new factory labor and cyber-service work are traits of classic proletarianization, which today exist in the intermediate strata between capital and labor, composed of people who design hardware and software for cybernetic systems, or who supervise, train, manage, and educate those working with such technologies. These middle-class jobs are recently menaced by the very dynamics of network outsourcing and automation which they help set in motion. As a result, more labor is performed by low-waged precarious employees or by equally (financially) insecure freelancers [49, 50, 51, 52, 53];
- **Social media free labor.** The Web 2.0 search-engine and social-media model depend on the upload of user-generated contents and search results [55, 56, 57]. Because new information are basically uploaded by Internet users, there is little need for companies involved in search-engine and social-media model, such as Google,

Twitter, Facebook and Instagram;

- **The increase of student workforce.** Universities and colleges have been recently attracting the children not only of capitalists and professionals, but also those of working-class families. These institutions, however, share tight connections with the high-tech sector, partially in order to respond to the needs of cybernetic capital, for which it functions as an incubator, market and supplier of low- or no-pay interns. [58]

Going to more recent times, cybernetics influenced the creation of the great 2008 crisis as well. That crisis, states Dyer-Witherford [38, p. 11], was generated by the middle-class weakness, so ironically it rose from the very aim that the introduction of cybernetics had in the 1970s: the defeat of the mass worker and the erosion of the welfare state in the global North created a problem at the consumption end of capital's circuit. Wages and social costs could be contained by automation and outsourcing, but a global low-wage economy with limited purchasing power generated overproduction and a shortage of investment opportunities. The 2008 crisis threw into the spotlight the underlying problem of cybernetic capital: its vast "oversupply" of labor relative to what capital was willing to wage. [59] This oversupply was (at least partially) generated by labor automation, which replaced work of all kinds. Cybernetics had enlarged the pool of workers on which capital could draw, but this same pool of un- and under-employed labor was the core of the general global proletarian problem, because its demand could not satisfy the growing offer from cybernetic supply chains (in the case of the 2008 crisis, the housing market), thus contributing to the generation of the chain reaction leading to the development of the crisis.

III. Conclusion

In section I we introduced the phenomenon of labor automation, with specific focus on whom it affects, since when and how it has evolved and the reasons behind its current popularity. We dove into the positive and negative consequences, the opportunities and the fears brought by this humongous event, by following the common thread of two main viewpoints about what we have to expect from labor automation: an optimistic and a skeptical one, respectively. We found that, on the one hand, (1a) AI systems can augment human labor or save it from the execution of repetitive and eventually dangerous tasks; (1b) automation has created new job positions, as skilled people are required to watch over the functioning and the usage of newly introduced machines; (1c) it should be an admonition to getting prepared for this supposedly inevitable phenomenon, by investing in proper education and gaining useful skills through it; and (1d) wariness against automation stems from a psychological defense of one's inner balance, which is threatened by the inevitably uncertain nature of the phenomenon in question. On the other hand, (2a) this wariness has evident bases to be felt, as the practical utility of human labor can be put into question compared with that of machines; and (2b) automation can accentuate inequalities between workers and individuals who profit from the computerization of jobs or tasks, both in terms of work conditions and social status, and in terms of wages. These inequalities have then been actually stressed by the Covid-19 pandemic, wherein many people, regardless of the pandemic itself having unprecedented effects, have been found unprepared to the radical acceleration of the paradigm shift because of an insufficient investment on retraining, which could postpone the obsolescence of affected workers.

Section II dealt mostly with an analysis of current developments in the introduction of computer based technologies into the workplace to regulate work. We began by giving an overview of the what regulation of work is and then gave an example of a historic way to regulate work, taylorism. Taylorism featured a tight control over the labor process by first analysing the motions a worker does to complete a work task, then decomposing it into atomized subtasks and lastly exercising maximum control over the way workers will execute these new subtasks. This marked a shift in power over the knowledge of work processes, in which a middle management would appropriate the workers knowledge through an analysis of the work. Specialized knowledge a worker used to have was now knowledge of the company. This changed the power dynamics of employee and employer. Next we discussed the cybernetic mode of control. Just as in taylorism the goal for the employer was to gain as much control over the work process as possible. Whereas taylorism focused on rigid control through analysis of the work, cybernetics focus on subjectification of work emphasizing self-regulatory processes of the worker. This allows managers to control workers even in environments where the mechanisms of tight, rigid regulation used in taylorism are not applicable because of a larger variance in motions and tasks that most work is characterized by today. Lastly, we finish our analysis with a discussion of far-reaching and lasting effects on the proletariat, that follow from an increase in cybernetic regulation. These effects are called cybernetic proletarianization and are caused by an increased removal of skills from work due to algorithmically generated instructions for the workers (deskilling), an intensification of work due to flexibilization of working conditions and increased algorithmic control through cybernetic devices and through automation, enabled through data gathered during the work processes from cybernetic control devices. This results in qualitative and quantitative expulsion from the workplace, which then forces workers to be reintegrated into the workplace in new and changed jobs characterized by an increased precarization of working conditions.

A. *Ethical Analysis*

After having discussed many possible nuances of labor automation in sections I and II, section III addresses how this phenomenon should be approached from an ethical point of view, given that we as computer scientists are involved in the design of computer systems and, therefore, are to some extent contributing to it. With this purpose in mind, we have chosen two philosophical currents to discuss the moral righteousness of labor automation: **consequentialism** and **deontological ethics**.

1) Consequentialism[17]: On the one hand, the fact that robotic systems perform well at tedious tasks improves the cost-benefit analysis [24]: for example, the usage of robots in assembly-line jobs solves many worker safety issues, by avoiding repetitive motion injuries. [25] They also help with other non-trivial scenarios, such as diagnostics [26] and cleaning up radioactive waste [27], and enable employers to schedule employees' tasks more flexibly based on costs, job-person fit and employee preferences [60]. [28, p. 25] Meanwhile, they have contributed to the decrease of the prices of goods produced by autonomous economy[18]: for example, the replacement of *Blockbuster Video* with *Netflix* and *RedBox* kiosks has led to a significant reduction of the prices of single movies [29], passing from $2,99-3,99 per title rental (Blockbuster On Demand) to $7,99 per monthly subscription and access to all films available in the platform (Netflix)[19].
On the other hand, the cost-benefit analysis faces some downsides too. To begin with, all fears presented in sections I-C and the consequences of cybernetic proletarianization presented in section II must be considered: for instance, one of the advantages mentioned before was the possibility for more flexible allocations of workers in terms of costs, job-person fit and employee preferences, but according to section II not only will costs and mere profit be prioritized, but also it is not guaranteed that this position does come along with a rewarding working condition. Then, [28] points out some potential violations of basic human rights (see Fig. 9): to quote some, the feeling of dispossession by side of human workers from the value and the purpose of carrying out their tasks or jobs [right to integrity of the person], the displacement causing workers to be pushed to more precarious and invisible forms of employment with a reduced income security; a possible commodification of labor [61] whereby workers are treated like commodities by devices able to decide about their actions; the possibility to discriminate the performance of workers based on parameters and act accordingly [right to liberty and security, right to non-discrimination]. [28, p. 20–21]

Consequentialism does not lean completely towards a univoque judgement of labor automation, because we saw in sections I and II that it brings very different types of consequences. All in all, however, despite the harm it might bring to a non-negligible amount of workers, labor automation can maximize the happiness of users receiving better quality services (e.g., Amazon), cheaper goods [29], etc. Therefore, consequentialism is more prone to supporting the righteousness of the phenomenon.

2) Deontological Ethics, or "AI is the solution, but what is the problem?": Deontologically, we have to address this

Table 4: Fundamental human rights impacted by the use of technologies in the workplace

Fundamental human right	IoT and wearables	Advanced robotics	AI
Right to human dignity (Article 1)	X	X	X
Right to integrity of the person, including mental integrity (Article 3)	X	X	X
Right to liberty and security (Article 6)	X	X	X
Right to respect for private and family life (Article 7)	X		X
Right to protection of personal data (Article 8)	X	X	X
Right to freedom of assembly and association (Article 12) and right to collective bargaining and action (Article 28)	X	X	X
Right to non-discrimination (Article 21)			X
Right to fair and just working conditions (Article 31)	X	X	X
Right to an effective remedy and a fair trial (Article 47)	X		X

Source: *Created by the authors based on the literature review*

Fig. 9. Table of the fundamental human rights that can be affected by the introduction of different kinds of technologies in the workplace. Figure taken from [28, p. 20].

problem on a different level. If we look at the effects of cybernetic proletarianization from a deontological view, then a quick judgement of the way algorithms are used currently to regulate the work of human laborers might conclude that this is immoral. Computers restrict workers autonomy, making them behave more and more like a machine. Repeating what one manager said about the introduction of algorithmic control systems, humans are becoming more and more a "slave to the machine" [87, p. 203]. This clearly contradicts the Kantian formula of humanity, forbidding the treatment of other humans simply as means to achieve an end that lies outside of them. However, judging the general idea of labor automation, this is not so easy anymore. Automating jobs that are dangerous for humans seems like a good action, making humans jobless to increase profit seems like a bad action. As we have seen in subsection I-E, AI technologies have been framed repeatedly as a great opportunity for good.

So maybe it makes sense to address this pervasive solutionism in order to judge their usage and ask: "If AI is the solution, what is the problem?". Currently the introduction of AI technologies seems mostly guided by economic principles. 'Is it cheaper to automate a task with a computer or is it cheaper to employ a human?' If the answer is 'computer' the task will be automated. The consequences for a society if a large amount of jobs are automated away don't seem to play a role in the decision. Similarly, if AI or other technologies would make a workers job easier and less dangerous for their health, but it is not economical, the technology will most probably not be used. A more ethical problem formulation would ask if the introduction of this computer technology would serve a more universal good. As Berendt [66] notes, the question of how to employ AI for the "common good" is gaining more and more interest. Instead of trying to judge the intentions of managers and companies in their introduction of AI systems, we will try to present an idea for an alternative framework in order to judge whether to introduce AI or cybernetic systems into the workplace or not, based on the four questions proposed in "AI for the Common Good?" [66].

First we should ask: "What is the problem?" [66, p. 50] Often, reasons for the introduction of cybernetic systems in the workplace have been marketed as an increase in autonomy for

[17]As this kind of ethics prioritizes actions which maximize general happiness and reduce suffering, the paper uses the cost-benefit analysis as method to evaluate the consequences of labor automation.

[18]The area where intelligent machines, robots, AI, big-data systems power the production of goods.

[19]https://www.cnet.com/culture/netflix-vs-blockbuster-whats-the-best-service-for-streaming-and-dvds/

the worker. As Pfeiffer [90] mentions, increasing the worker's autonomy was also framed as one of the goals of Industrie 4.0. Though in reality, this often meant workers were free in deciding how to best fulfill the goals given to them by the company, as Jochum [83] notes. Similarly Gensler and Abendroth [79] have reported that workers often feel powerless and challenged in their autonomy when presented with automatically generated instructions. In general, as discussed in section II, cybernetic control systems are mostly introduced to regulate a worker more rather than to increase their autonomy. Consequently, we propose to rather really ask: "How can we increase a workers autonomy over their job to improve their work situation?" Increasing a worker's autonomy puts them in charge to judge whether an AI system will benefit them or not. As Berendt [66] notes, different groups of people have different ideas about the Common Good. By putting the worker in charge to decide what is good for their work situation and what isn't, this Common Good might be more achievable.

This already touches on the second question proposed: "Who defines the problem?" [66, p. 51] If we ask the worker to judge what they need of their workplace, we consult one of the main stakeholders affected by the introduction of computer systems. However, things are not that easy. Different stakeholders may hold different stakes: for instance, a factory floor is not made out of workers with homogeneous needs, what may be beneficial for one may be detrimental to the other. It is not always possible to find a common ground satisfying everybody. Still, having people working in a workplace decide democratically how they want to shape their environment may not always satisfy everyone, but it seems more fitting than an outsider deciding for them.

The next question asks: "What is the role of knowledge?" [66, p. 53] When Uber drivers were interviewed, they often reported a desire for tractability of computer generated instructions [85]. We propose that algorithmic systems supporting humans are designed in a way where information is presented in a way that is understandable for a human worker. It should be clear how some information was gathered, judged and presented: for example, if AI generated statistical recommendations are presented, their confidence probabilities should also be shown, so that a human can gather the likelihood of the outcome of a decision based on these information. At the same time only relevant information should be presented, not more [66].

Lastly, we need to ask "What zare important side-effects and dynamics?" [66, p. 56] When increasing the autonomy of the worker, we also increase their cognitive load. If a worker has a lot of work to do, having to also attend several work council meetings to decide on different aspects of their workplace might seem like an additional factor of stress. This is why we need to be aware of the amount of workload we can give a single laborer and help them by making decisions easier through framing them in a salient way.

This is of course not an exhaustive framework and creating one would be a much bigger task. Still we would argue that it is a step in a direction that better serves the "Common Good" rather than the current objectives that are guiding the introduction of AI and algorithmic systems in the workplace. Also these answers avoid the pervasive problems of solutionism that is prevalent in much of the discussion of these systems. It is not the technologies that are decisive in the way they influence the lives of the human workers, it is the way they are introduced that causes many of the problems discussed. As Schaupp [94] mentions, the introduction of technologies in workplaces is always accompanied by conflicts of interest among different groups of stakeholders. As we have shown, the interests of the workers themselves are in these cases seldomly of concern. However, if AI is created for the Common Good, their interests have to be accommodated as well, which is what the focus of our proposal tries to emphasize.

B. *Final Remarks*

In the end, we intend to leave some admonishments, considering all that has been written:

- We should be aware of all possible implications of labor automation, not only because it is an unstoppable phenomenon, but also because we as computer scientists be directly responsible for designing those systems which may influence the job future and/or perception of other fellows;
- Machines may be seen as a threat by those who haven't had or don't have the possibility to have an adequate background in the field: it is our duty not to leave them in despair and explain them what is happening and what they could potentially do to react;
- We should neither reject the algorithmic utility of AI systems, nor discard the polyhedric versatility of a human worker, but rather find a way of coexistence for both entities for the sake of future society. The economy suggests a stronger deployment of technologies, but it is also true that markets are inherently bad at delivering the human element, therefore, if progress solely follows the choices of markets, human future will depend on their shortcomings and failures [40]. This stresses the need for new technologies to be shaped according to our common values.

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