The Future of Work in the Age of Automation: Proceedings of a Workshop on Norbert Wiener's 21st Century Legacy

Heather A. Love, *Member, IEEE*, Greg Adamson, *Senior Member, IEEE*, Mallory James, *Member, IEEE*, Jason Lajoie, Iven Mareels, *Life Fellow, IEEE*, Zach Pearl, Daniel S. Schiff, *Member, IEEE*, Ketra Schmitt, *Member, IEEE*, Thirumala Arohi, John Buchanan, Stéphanie Camaréna, *Associate Member, IEEE*, Marten Kaevats, *Member, IEEE*, Jeremy Reynolds, Pedro H. Albuquerque, *Senior Member, IEEE*, John C. Havens, Davis Chacón-Hurtado, Sucheta Lahiri, Ayse Ocal, Alexi Orchard, Michael Rigby, *Member, IEEE*, Rebecca Sherlock, Victor Sundararaj, and Qin Zhu, *Member, IEEE*

***Abstract*—This article synthesizes the insights gained through presentations and discussions at the 2023 IEEE Workshop on Norbert Wiener in the 21st Century (21CW2023), which focused on "The Future of Work in the Age of Automation." Hosted at Purdue University, this interdisciplinary convening of technologists, social scientists, and humanists explored the impacts of automation on labor, drawing on Wiener's legacy of insights as a backdrop to examine the technologically mediated future we face in coming decades. The workshop presented a rare opportunity to reflect critically on these issues at a pivotal moment in human and technological history, and to elicit underappreciated dimensions. Areas of focus include: the qualitative and quantitative losses associated with automation and AI, the impacts automation has for questions about the meaningfulness of work, the challenges we face related to uncertainty and lack of predictability in technological advancement, and the opportunities that exist for centering human values and agency in these conversations. While acknowledging many items for concern in the context of automation in the future of work, such as the domination of economic narratives, a potential loss of qualitative texture, and the neglect of certain issues key to human identity, the authors conclude by offering optimistic visions—or calls—for redefining value and labor, preserving human agency, and embracing creative problem-solving.**

***Index Terms*—Future of work, automation, Norbert Wiener, cybernetics, technology ethics, artificial intelligence, meaning of work, ethical innovation, limits of predictability.**

I. Workshop Overview and Objectives

THE 2023 IEEE Workshop on Norbert Wiener in the 21st Century (21CW2023) was the fourth iteration of the Twenty-First Century Wiener (21CW) conference series, organized by the IEEE Society on Social Implications of Technology (SSIT).[1] 21CW2023 was held on Thursday, 18 May 2023 in affiliation with SSIT's IEEE ETHICS 2023 conference at Purdue University in West Lafayette, Indiana. The by-invitation, daylong event focused on the theme "The Future of Work in the Age of Automation," a topic about which MIT mathematician and "father of cybernetics" Norbert Wiener had many things to say (see [6], [7], [8], [9]). Wiener's rich body of work covers many topics that could serve as the basis for workshop discussion (organizers also considered highlighting his early work on the environmental crisis and his interest in assistive medical technologies); we ultimately selected the 2023 theme due to its urgency during this significant moment in the development of "artificial intelligence"—a term chosen by John McCarthy in 1956 in part to *avoid* association with Wiener's "cybernetics" [10, p. 6].

Indeed, numerous recent publications on the "future of work" from across academic, industry, and government sectors point to the significance of this topic. Perspectives range widely: enthusiastic endorsements of specific products [11] and playbooks for AI adoption [12]; more measured stock-taking exercises and literature reviews [13], [14], [15]; and critical arguments about the impacts of automation on the human workforce and the specific responses that could mitigate those effects [16], [17], [18], [19], to name only a few examples. From edited collections [20] and journal special issues (see the full issue that [21] introduces) to international conferences [22], standards work [23], [24], and collaborative reports (such as the one produced by the IEEE Industry Engagement Committee and IEEE Computer Society on the "Future of the Workforce" in 2022 [25]),

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Please see the Acknowledgment section of this article for the author affiliations.

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[1] Previous iterations of the conference took place in 2014 (Boston, MA, USA), 2016 (Melbourne, VIC, Australia), and 2021 (Chennai, India–virtual event). In addition to the three Conference Proceedings available through IEEE Xplore [1], [2], [3], work from (and generated in response to) earlier events appears in two special issues of *IEEE Technology and Society Magazine* (vol. 34, no. 3, Sept 2015 [4]; vol. 36, no. 2, June 2017 [5]).

much of this work is deliberately interdisciplinary and wide-ranging in scope, an ethos that we similarly bring to the table.

In the spirit of the Macy Conferences [26], [27], through which Wiener developed many of his ideas, 21CW2023 was designed to foster multi-disciplinary conversation and debate [28]. As with those mid-twentieth century events, and in keeping with more recent scholarship on approaches to so-called "wicked problems" [29], one of the meeting's key premises was that we must find creative ways to bridge what are often deeply entrenched disciplinary silos between STEM, HSS (humanities, social sciences), and fine arts domains if we want to tackle complex socio-technical problems in nuanced, ethically oriented, and technically savvy ways. Presenter expertise therefore encompassed fields from across all three of these areas (see author biographies). Following from a previous successful workshop that Mareels had been part of [30], the format was set up to provide participants space and time to learn from one another about a topic of shared interest, encounter and engage with unfamiliar perspectives, and collaboratively develop potential approaches to the problems surrounding the issue at hand.

Participants ranging from emerging to well-established scholars and industry professionals travelled to the meeting from North America, Europe, and Oceania. The workshop was divided into four 75-minute sessions, each of which featured brief prepared remarks from three or four presenters with different disciplinary backgrounds and expertise related to automation, work/labor studies, and/or Nobert Wiener's work (see Appendix A in the supplementary material for the complete Workshop Program). Presentations were designed as "provocations"—that is, they were meant to elicit responses, delve into controversial issues, and pose challenging questions to the group. Each set of presentations was followed by moderated group discussions. *Those ensuing discussions constitute the essence of the workshop proceedings*, which we are pleased to present here.

Prior to the workshop, participants had access to pre-reading material drawn from Wiener's writing thematically related to the "Future of Work in the Age of Automation." In addition, they read a selection of recent media articles concerning the effects of automation on labor ([31], [32], [33], [34], [35], [36], [37], [38], [39], [40]), and the opening section of Kurt Vonnegut's *Player Piano* [41] (1953), the subject of which resonates in many ways with Wiener's dystopian vision regarding the threat that automation poses to human work. This common set of references was woven into the group's discussions, insights, and reflections.

Those sources also point to the new contributions that these proceedings make to the already rich literature on the future of work theme. Our goal at the workshop—and in developing the core arguments in these proceedings—was to engage with and advance current debates from a perspective grounded in (a) Wiener's staunchly ethical stance towards technological innovation, and (b) his commitment to cybernetics-based understandings of the complexity and unpredictability of modern socio-technical systems. A. Ganapathy and M. T. Bennett's paper on "Cybernetics and the Future of Work" (presented at the 2021 Norbert Wiener conference) offers a helpful framing for our objectives: as they put it, Norbert Weiner's work and the ideas embedded in the "origin story of cybernetics … serve to illustrate how we may better understand present complex challenges, to create a future of work that places human values at its core" [42, p. 1]. In what follows, we mobilize this formulation to showcase the insights that emerged through sustained dialogue, guided by subject-area experts from multiple disciplines, and grounded in the idea of Wiener's work boasting an enduring legacy in the 21st century.

We begin with an overview of our Methods for developing these proceedings (Section II) and then present a synopsis of Wiener's perspectives on the workshop theme (Section III). This material provides a conceptual backdrop for the main body of these proceedings: a "Prelude" that offers an historical framing for the discussion of contemporary labor and automation issues (Section IV) and a series of short, thematic essays that synthesize and present key insights that emerged from the day's discussions (Sections V–VIII). The "Conclusions and Next Steps" (Section IX) outline opportunities for future research and engagement on the "Future of Work" theme, and we close with a consolidated set of "Key Takeaways" for readers (Section X).

II. Methods

During the workshop, multiple audio recording devices, designated notetakers, and ad-hoc doodling and mind-mapping activities captured records of the four workshop discussions that followed each of the speaker sessions (see Appendix B in the supplementary material for examples). In addition to these records, participants completed a brief survey at the end of the workshop reporting on the key takeaways that had emerged for them during the day's discussions, and several invited speakers contributed their own notes from the meeting to the collective synthesis process. The workshop materials, notes, and experiences [43] thus constitute the data underlying these reflections, with the workshop itself serving as "design studio," centering interdisciplinarity, open participation, and intellectual stock-taking [44].

While analyzing the material and developing the proceedings, we elected to take the information out of the temporal sequence of the original meeting and consolidate the key takeaways, insights, and connections into a theme-based structure. Speakers who wanted to participate in this process convened in three international online meetings in June 2023. Drawing on an inductive, thematic analysis approach [45], several authors (M. James, J. Lajoie, H. Love, I. Mareels, D. Schiff, K. Schmitt) identified cross-cutting themes, elements, messages, threads, or topics from within the 21CW2023 workshop documentation. The primary analytical strategies for distilling themes were identifying repetition, similarities and differences, and cutting and arranging amongst these data [46]. In order to reach convergence, the core author team both drew on their unique disciplinary lenses and looked for concepts that would transgress those boundaries [47] and interface with multiple perspectives. Working collaboratively, the group

ultimately selected five main topic areas for body sections of the proceedings (Sections IV–VIII).

To scaffold this effort, the group considered using a sequence of Norbert Wiener's concepts and concerns as a structural "spine" for the proceedings but eventually elected against this organizing principle, because much of what had been discussed during the workshop appeared to have created lines of flight from Wiener's thinking, centering contemporary industrial, social, and political issues outside of Wiener's primary frames of reference. Instead, Section III presents a brief account of the content in Wiener's writing most directly related to the workshop theme; this account serves as a backdrop to subsequent essays.

During the planning meetings, a writing lead and supporting authors were appointed for each topic area (Table I). Their task was to look over the whole set of materials in relation to that theme and create a first draft report for that subtopic. Drafting, group consultation, and revision took place throughout the 2023–2024 academic year. Prior to publication, all workshop presenters and participants had the opportunity to provide feedback and revision suggestions. The following essays synthesize, reflect upon, and articulate the through-lines and insights that the workshop inspired; we hope that you find this work generative.

TABLE I
AUTHORS FOR MAIN PROCEEDINGS SECTIONS

Section	Lead Author	Supporting Authors
III: Norbert Wiener's Thoughts on the Future of Work	H. Love	M. James, I. Mareels, G. Adamson
IV: Prelude: Luddites, Looms and Labor Organizing	K. Schmitt	J. Lajoie, I. Mareels
V: Qualitative and Quantitative Losses	D. Schiff	M. James, I. Mareels, H. Love
VI: Meaningfulness of Work	M. James	D. Schiff, H. Love
VII: Limits of Predictability	I. Mareels	J. Lajoie, H. Love
VIII: Opportunities for Incorporating Values and Agency	J. Lajoie	K. Schmitt, H. Love

III. NORBERT WIENER'S THOUGHTS ON "THE FUTURE OF WORK"

A. *Wiener's Direct Engagement With Labor Organizers*

"The Future of Work in the Age of Automation" was an ongoing concern for Wiener. From the 1940s to the 1960s, as he developed mathematical theories of and approaches to automation, he also considered the impacts such automation might have on both physical labor and white-collar jobs. Indeed, he repeatedly championed the notion that technology developers must consider the social and economic as well as the technical dimensions of technological change.

Perhaps Wiener's clearest and most succinct exposition of the threat that automation could pose is found in his 1949 letter to Walter Reuther, President of the Union of Automobile Workers (Detroit, Michigan, USA) [48]. Early in the letter, he states: "I have been interested for a long time in the problem of automatic machinery and its social consequences," and he explains that the "situation has been brought to a head by the fact that I have been approached recently by one of the leading industrial corporations with the view to advising them as to whether to go into the problem of making ⋯ artificial control mechanisms, as part of their extended program" [48]. After outlining what he could easily provide to the corporation if he desired to support its quest for automation, he shifts to a more ominous tone, proclaiming that automated machines "will undoubtedly lead to the factory without employees; as for example, the automatic automobile assembly line," and presaging that "in the hands of the present industrial setup, the unemployment produced by such plants can only be disastrous" [48]. More philosophically, he also recognizes the existential implications of participating in the race to automate: "I do not wish to contribute in any way to selling labor down the river, and I am quite aware that any labor, which is in competition with slave labor, whether the slaves are human or mechanical, must accept the conditions of work of slave labor" [48].

Within the letter, this warning of technology's impending impact (not only on the human workforce but also the very signification of the term "labor" within society at large) is paired with a series of statements displaying Wiener's sense of responsibility. He staunchly believes that technical experts should warn those whose livelihoods are under threat, since "for [people like Wiener] merely to remain aloof is to make sure that the development of these ideas will go into other hands which will probably be much less friendly to organized labor" [48]. Therefore, although he has "turned down unconditionally the request of the industrial company which has tried to consult me," he is now contacting Reuther to offer his services in aid of workers [48].

B. *Against "Gadget Worshippers" in God & Golem*

Wiener's disdain for uncritically enthusiastic technologists—and his perception of greed as a primary driver of technological development—also appears in his later writing regarding "gadget worshipers," a term he used to refer to those who believed in some necessarily beneficial trajectory of technology [49, p. 53]. This perspective is summarized most clearly in his final work, a short and synthetic piece called *God & Golem, Inc.* [49] (1964). In Chapter V of that text, Wiener blends contexts, metaphors, and references to religious traditions (Judaism/Christianity) and economic models (Marxism/capitalism) to explore the tensions between the pursuit of new knowledge and innovation—of which the development of automata can be a beneficial part—and

the mobilization of this knowledge for selfish or destructive aims:

> There is a sin, which consists of using the magic of modern automation to further personal profit or let loose the apocalyptic terrors of nuclear warfare ⋯ As long as automata can be made, whether in the metal or merely in principle, the study of their making and their theory is a legitimate phase of human curiosity, and human intelligence is stultified when man sets fixed bounds to his curiosity. Yet there are aspects of the motives to automation that go beyond a legitimate curiosity and are sinful in themselves. These are to be exemplified in the particular type of engineer and organizer of engineering which I shall designate by the name of *gadget worshipper* [49, pp. 52–53].

The chapter ends with a speculative projection of how humans and machines are likely to interface and interact with one another as technologies develop further: "The world of the future will be an ever more demanding struggle against the limitations of our intelligence, not a comfortable hammock in which we can lie down to be waited upon by our robot slaves" [49, p. 69]. The nod to labor here is oblique, i.e., couched within his refutation of the belief that one day humans will *not have to* engage in tedious labor. But it nonetheless informs this vision of humans struggling to manage the unexpected consequences of the tools they have developed. As *God & Golem* indicates, Wiener maintained a rather pessimistic stance with respect to our ability as a society to impose an ethical framework on the development of automation. Ironically, especially in light of our discussions of failure, limitations, and values during the 21CW2023 workshop, Wiener suggests that the struggles we experience due to inadequate ethical oversight of automation and artificial intelligence may be a consequence of our own limited intelligence.

C. Humans in Competition With Mechanized Labor

Outside of mathematics circles, Wiener is perhaps most famous for two books, both of which include references to the workshop theme. *Cybernetics, or Control and Communication in the Animal and the Machine* [50] (1948; 2nd edition 1961 [51]) provides a broad and somewhat mathematical description of his approach. The topic of automation appears in the final pages of the book's "Introduction," where he prophesies that "the automatic factory and the assembly line without human agents" are likely to arrive sooner than expected, especially if concerted efforts are dedicated to their development ("as was spent ⋯ in the development of the technique of radar in the second world war") [50, pp. 36–37]. The discussion here emphasizes Wiener's conviction in automation as an ambivalent force, with "unbounded possibilities for good and for evil" [50, p. 37]: on the one hand, automation can provide humanity with "a new and most effective collection of mechanical slaves to perform its labor," while avoiding "the direct demoralizing effects of human cruelty" [50, p. 37]; however, if used for evil ends, the result will be to place humans in "competition" with mechanized labor, essentially "accept[ing] the conditions of slave labor" for wide swaths of the human population [50, p. 37]. Wiener's larger argument—which dovetails with many of the ideas that emerged during the course of our workshop discussions—emphasizes the need for a widespread shift in perspective across social, economic, and political realms. As he puts it: "The answer, of course, is to have a society based on human values other than buying or selling" [50, p. 38].

A version of these ideas explicitly addressed to non-mathematicians can be found in *The Human Use of Human Beings* [51] (1950). The title, proposed by Wiener's editor, Paul Brooks, comes from Wiener's wording in the book's first chapter. Here, he describes his ambitions for the project as "a protest against this inhuman use of human beings" [52, p. 16], referring to the dehumanizing effects of modern day labor in venues such as corporations, government structures, and assembly line production facilities (see [53, p. 80]). Notably, the title also echoes Immanuel Kant's famous dictum, "*So act that you use humanity, in your own person as well as in the person of any other, always at the same time as an end, never merely as a means*" (italics in original) [54, p. 41]. In his 1950 book, Wiener presents an expanded discussion of the changes and disruptions he anticipates automation will impose upon the labor sector (from the "assembly line" to "clerical work" [52, p. 185]). He outlines a more specific timeline for when he projects these changes will occur (within "ten to twenty years," or faster if another war intervenes to spur technological development [52, p. 187]), and he presents a more in-depth overview of the "economic and social consequences" of these technological developments [52, p. 188]. Wiener reiterates his dire predictions for employment, envisioning "an unemployment situation, in comparison with which the present recession and even the depression of the thirties will seem a pleasant joke" [52, p. 189].

D. Technologists' Ethical Responsibility

Finally, a summary of the dilemma faced by the technology producer appears in the second part of Wiener's autobiography, *I Am a Mathematician* (1956) [55]. Here, while musing on his ethical concerns about the atomic bomb, and the "very deep searching of soul" it prompted in him, he writes about his internal deliberations regarding whether to keep quiet about his knowledge regarding the impending disruptive potential for automation and simply hope that the technologies would not come to fruition [55, p. 308]. In the end, he opts for "a position of the greatest publicity" and a commitment to communicate with strategically selected audiences about what the risks of automation really were—a decision that results in his approaching officials of two prominent labor organizations, including the typographers' union [55, p. 308]. Yet, the audiences Wiener selected largely ignored his warnings, deeming his dire predictions too far off and far-fetched to merit immediate responses. As Adamson's presentation at the 21CW2023 workshop recounted, the decimation of typographers' jobs took place with the advent of desktop publishing in the mid-1980s—four decades after Wiener's warning.

Looking back on Weiner's writings allows us not only to note their prescience but also to consider their continued relevance in the context of our twenty-first century world. As you read through the upcoming sections of these proceedings, we encourage you to circle back to these summaries of Wiener's work (or even to consult them in their entirety!). We hope that the synopses we have provided of the discussions that took place at the 21CW2023 workshop will offer generative links to Wiener's concrete ideas and predictions about technological developments in automation and, also, to his convictions about the ethical responsibilities of technologists [56] and their positions of agency within modern socio-technical, economic, and political systems.

IV. Prelude: Luddites, Looms, and Labor Organizing

Amidst dominant cultural narratives of technological advances [57], calls to resist technological change (or efforts to speak out against the social and economic damages it produces) can easily be equated to holding up progress. This move can seem inevitable. Society has been here before. Take, for example, the Luddite movement. As R. Coniff explains, the Luddites were active during the late-stage Napoleonic Wars from 1811–1816, and they used collective action to resist the introduction of automated (and also algorithmic) looms [58]. Objectively, these early examples of automation provided more dangerous working conditions, generated products of lesser quality, and resulted in lower pay compared to previous, human-expert-based weaving processes. Despite all these downsides, the economic and productivity gains were impressive. Moreover, the automation fomented an ethos—and, eventually, a perceived *imperative*—of continuous improvement totally underestimated at the time by all involved.

The reasons that weavers and other nineteenth century workers tried to organize and demand better working conditions and fight pay losses in the face of rapid inflation (due to war conditions) are clear. The Luddite movement was not the first of its kind, and precedents are documented from as early as 1675 [59]. The Luddite movement resorted to unlawful and well-coordinated action, often including the physical destruction of the new looms. Its brutal suppression was endorsed through an act of parliament in favor of big business that ignored the Luddites' cause. Indeed, very few in the establishment of the day defended the Luddites. Lord Byron (and his "maiden speech in the house of Lords" [60]) was one such exception.

What is relevant to our discussion is the single-minded governance response to the Luddite-like movements of the past. The actors in industry and government, as proponents of progress, focused first and foremost on economic supremacy. This nineteenth century narrative served the interests of industry actors wishing to cast laborers as dangerous, property-destroying radicals who opposed progress. Winners and losers were chosen on the basis of a purely economic argument, ignoring the humanity of the Luddites, citizens of the realm. Significantly, "Luddite" lingers in our cultural shorthand as a pejorative term used to label someone as backwards and dismiss their concerns about innovation as anti-technological, anti-progress, even anti-capitalist. However, the continued use of this label ironically stresses the persistence of the very issues Luddism sought to warn people about.

After all, as authors such as Brian Merchant have argued [61] amid twenty-first century technological transitions, we find ourselves once again at the same crossroads. We are asked to accept essentially the same deal that those dispossessed factory workers of the past rejected: that displacement is an inevitable by-product of innovation, with negative consequences being outweighed by the benefits that innovation provides to human potential. It appears that, as a society, we have not yet resolved how to cope in a civilized manner with the key issue of human displacement by technology. What we find instead, just as those Luddites found centuries ago, is that innovation continues to benefit those with the means to control it, typically with few to no protections in place for whatever or whomever falls behind. This echoes the pervasive discrepancies between those who "have" and "have not." Despite all productivity gains and raising of the floor in terms of global poverty, and despite our presumed heightened consciousness as a society, inequities seem to persist or grow rather than diminish [62], [63].

It behooves us to understand why the Luddites were opposing progress. Their narrative and point of view is worth grappling with alongside present productivity rhetoric from automation proponents that stresses the capacity of AI to augment human abilities through "personalized logics," e.g., that every office worker can have a personal secretary, every student can have a personalized tutor, every citizen can access personalized government services at scale [64] (similarly structured narratives from media and industry appear in [65], [66]). These claims are not inherently false, but just as those Luddites illustrated for us centuries ago, the benefits of innovation tend to accrue to those people—or indeed those communities and even nations—who already occupy positions of power and privilege, while unintended (or intended) consequences fall on the rest. Much of our automation technology does have the potential to scale exponentially, and twenty-first century advances in AI pose novel forms of disruption to different workplaces not previously affected. While the metamorphosis and diversification of AI software applications continues relatively unabated, calls for combatting inequality, environmental degradation, and dire poverty are falling into the background behind celebratory, optimistic, and enthusiastic framings of "innovation."

To create progress within our notion of "progress" itself, let our conversations be increasingly focused on the preservation of essential human rights, the meaningfulness of work, life, and well-being. Rather than accepting celebratory narratives of technological progress at face value, we should leverage the opportunity as our predecessors did (and perhaps successors will), to explore the finer points of how these technological and economic systems work—how they could work with us, and especially how they "work us over."

V. Proceedings Part I: Qualitative & Quantitative Losses

At the entryway to a new industrial transition, we hesitate, concerned that amidst enthusiasm to invest in technological change, both quantifiable and unquantifiable social harms from these changes may be simply ignored. We seem beholden to an economistic, techno-optimistic, deterministic narrative even when we (like Wiener) know this is not quite right. This seems to be what is taking hold in the GenAI moment and shaping the market and discourse. We fail to account for the assumptions baked into so many of our mental models, or to make a serious effort to quantify benefits and harms over long-term as well as transition costs, leading to sloppy and harmful thinking and decision-making around the future of work. The current direction poses serious risks for qualitative aspects of experience, including meaning, creativity, engagement in the actual activities that workers "signed up for," and relationships. Most people have not grappled with this, and it is an urgent concern that's worth exploring and perhaps resisting.

A. Twenty-First Century Technology Narratives

Many workshop participants, irrespective of background or degree of techno-optimism or -pessimism, positioned themselves as reacting to a pervasive narrative of technological change. The technologists, social scientists, and humanists alike, engaging with each other during a moment when substantial transformation feels imminent, characterized this narrative according to its emphasis on economic thinking, productivity, net benefits, and accompanying terms such as "innovation" or "synergy." It is a story of technological determinism, where new tools, advanced by and implemented throughout the economic system, herald the ongoing, steady march of human progress. Despite the largely shared understanding that technological development is not in fact simplistically deterministic [67], one would be hard-pressed to think otherwise from the sense of inevitability, the scale of the structural forces at play, and the relative lack of agency expressed by participants.

The familiar narrative goes as follows: technology results from innovation, a force majeure. This innovative technology inevitably leads to disruption. Perhaps it threatens individuals invested in the status quo, but the disruption is necessary, and resistors are merely holding back beneficial progress. Any destruction is creative [68], leading to assumed economic benefits, and the less-commonly stated implications of those benefits for other spheres of life (political, interpersonal, etc.). This narrative can feel irresistible, especially as one watches change taking place before their eyes over a short time [13].

Whether cautiously optimistic, profoundly disturbed, or simply uncertain about the status of this narrative, participants seemed to react as if this force were construed as a default, a law of nature. Yet they also questioned the narrow rendering of the narrative, drawing the group's collective attention to cases where it fails to pay attention to its own constituent assumptions. To take one specific example, participants noted that significant challenges emanate from a future of work mediated by AI, including potential harms which are rarely identified or measured in the narrative. As a starting point for this synthesis of workshop discussions, we highlight two key themes:

B. Winners vs. Losers: Binary Thinking, and the Neglect of Unquantifiable Costs

Social and policy discourse around the future of work often takes a surprisingly binary orientation. Sceptics are scolded as Luddites: who would argue for the use of horse-drawn carriages over vehicles powered by internal combustion engines, given the latter's benefits to the economy and society? Who would defend the preservation of agricultural economies when service-based economies come with so many benefits? On balance, newer technologies, disruptive though they may be, appear as a winning choice. Indeed, it's not uncommon for regulatory analysis to rely largely on net benefits when deciding between policy alternatives, in part owing to its heritage in the economic sciences, with their focus on welfare maximization [69]. Based on this understanding, it may seem straightforward that AI and automation will be good. Good for work, good for the economy, better than *not*-AI or *not*-automation.

Yet even the scholars who rely on these analytical methods proceed with an understanding that comparing net benefits versus costs is an incomplete approach [70], [71]. Economists look not only at whether a new technology is welfare-improving overall, but also whether it is Pareto-optimizing or Kaldor-Hicks efficient, i.e., ensuring no one is made worse off if some are made better off, or noting that welfare gains that accrue to a subset of individuals are only beneficial for all if there is post-hoc redistribution [72]. This is not dissimilar from the Rawlsian notion of justice in political philosophy, where the difference principle requires that one could only "raise all boats" if the *least* privileged are advantaged at least as much as the *most* [73], [74]. Consequently, morally serious policy analysts must look not only to cost-benefit analysis but also to distributional effects, environmental effects, and impacts on vulnerable groups. Understood broadly, political philosophers and sociologists recognize that justice and social stratification cannot be assessed merely through a binary determination of net benefits. Similarly, humanities scholars often attend to hierarchies of power in their analysis of cultural texts and contexts, viewing these as indispensable in understanding economic and social systems.

In short, numerous disciplinary perspectives recognize complexities that can unfortunately become flattened when narratives become binarized (even if we understand that decisions sometimes *are* binary—a project proposal is funded *or not*; a worker's job is retained after reorganization *or not*). This encourages us to examine the overlaps, tensions, and ways in which important goals like justice, distributional fairness, or meaningfulness could be reinvigorated in the context of understanding social implications of technology—and of taking interdisciplinary communication and collaboration seriously.

Furthermore, while these frames and disciplines are useful in considering the impacts of automation and new sociotechnical systems on human welfare as well as the distribution of benefits and costs related to these technologies, it is equally important to point out that these analyses and discussions tend to occur *after* technologies have been developed if not deployed. Beyond some pre-deployment mitigations or post-deployment monitoring, governments neither fully control nor regulate their impacts, especially second-order effects. Therefore, assessing their direct benefits and costs becomes primarily an academic exercise that is taken as grounds for advocating for marginally more or less regulation. Such an analytical lens, focused on economizing impacts, only modestly engages with whether or how these new technologies impact qualitative aspects of working life, like working conditions or meaningfulness, much less the broader social fabric.

In the future of work discourse, what are the implications of focusing on net benefits and overlooking even basic dimensions of technology forecasting, i.e., ignoring distributional effects, adjustment costs, implementation context, social movements, occupational deprivation and alienation, and strategic adjustment? For one, decision-making around adaptation could become sloppy. We might excuse major job losses in the interest of net benefits but then fail to actually implement reform in the educational system, job training sector, or other aspects of the social safety net. That is, we might asymmetrically invest in the creative aspects of destruction which proffer economic benefits for ourselves, our firms, and our countries, while ignoring the destructive effects of these initiatives on social systems and public institutions for which stable, predictable growth is a necessary condition. With our attention locked on narrowly defined success metrics, we might fail to appreciate even quantifiable harms related to social disruption, environmental degradation, lack of political cohesion, decreases in institutional trust, negative effects on health due to losses in occupational meaning, structural impacts on the length and cost of our educational system for the young and our social security systems for the elderly, and more.

We ignore these issues at our peril. After all, income inequality is associated with reductions in social cohesion and physical and mental health [75], while unsustainable practices undermine the foundations of human and economic viability in a self-defeating fashion [76]. Growing social inequality was already a problem before twenty-first century AI threatened job security, and extensive evidence has demonstrated the broad social and economic harms from even the present trend [77]. AI-generated job loss is poised to exacerbate the existing trend of job precarity and loss, and there are sound reasons to believe that the effects of AI on employment could worsen the negative consequences of increased inequality [78].

To frame these concepts in economic terms, the costs of economic disruption can accrue over time, erode structures that underpin and enable the formally visible economy, and be especially volatile during technological transition itself. Job insecurity, decreases in job quality, worker disengagement, and staff turnover are expensive, costing at least hundreds of billions of dollars a year annually [79], [80]. Poor policy planning that fails to invest in infrastructure, preventative healthcare, sustainability, adequate education, and comprehensive media literacy can likewise lead to decades of stagnation and untold trillions in opportunity cost. In short, history suggests there are usually winners and losers. Recent discourse suggests we are willing to adopt binary thinking [81] to avoid having to confront the existence of the latter category, and that we adopt short-sighted and inefficient approaches to quantification even when our analytical traditions know better [82].

C. Loss of Qualitative Texture

Beyond a narrow approach to quantification, workshop participants also highlighted potential costs for the qualitative aspects of work and life. A central insight in the context of work is that AI-boosted productivity can, in fact, lead to a change in job tasks such that the individual loses subjectively valued aspects of their work. Returning to the example of the farmer or horse-drawn carriage, we can imagine the qualitative losses of economic transformation. Indeed, there were major movements in the twentieth century lauding the values of agricultural labor, connection with one's work, immersion or immediacy rather than alienation, and the community aspects of agricultural life [83]. Abandoning the horse-drawn carriage implies, for example, losing the aspects of caring for horses (husbandry), including valuable skills and relationships, closer engagement with nature, or the joys of traveling through an open space. It's not a coincidence that horse-drawn carriages are now considered a luxury expense in advanced economies: traveling through Central Park in New York City via horse is a treat for a special occasion. Meanwhile, algorithmically moderated gig work via ride-sharing apps likely fails to preserve some of these sensory and emotional textures of transportation, even while it brings about other desired effects and efficiencies. Furthermore (to be *partially* tongue-in-cheek about it), from the perspective of the horse, automobiles posed an existential threat [84]. Qualitative change in how services are made available is not monotonically good, and often goes unexamined.

We can extend this logic to many jobs. The truck driver who perhaps enjoys the liberating sensation of the open road but may now spend most of the day sitting in the passenger seat reviewing shipping manifests, or simply observing or supervising a small fleet of driverless trucks on the road. The educator who enjoyed social engagement with their students but now strolls up and down the classroom as students interact with intelligent, personalized tutoring systems, and mainly deploys human judgment to adjudicate and take responsibility for plagiarism accusations initially flagged by software. The artist who appreciates and actively responds to how texture develops on a painted canvas but now works on a computer merely typing in prompts and curating a program's automated responses, suggestions, and even visual output. Are these individuals still objectively "employed" in transportation, education, and the fine arts? Certainly. But are they engaged in the activities they enjoyed when they elected to pursue these

professions and devote substantial time to training, education, and developing mastery of and pride in their work?

Indeed, workshop participants identified that individuals in creative professions, in particular, may undergo a diversification of their responsibilities in the wake of technological change. Some tasks are likely to be watered down while other more mundane tasks, workflows, and performance metrics accrue. To engage in some speculative imaginings: educators may become computer dashboard reviewers and coordinators of data entry, survey distribution, and repeatable video lecture and email messages across modular course timelines, while artists might become software-based project managers, and writers prompt generators and copy editors of chatbot-generated text. The tasks that are watered down and crowded out may be the very activities that create pleasurable experiences of deep absorption in work known as "flow," or they may be the traditional tasks associated with the profession over its longer history and hence generative of occupational identity and meaningfulness, or perhaps simply the ludic joy of material engagement as a form of play and discovery. Nevertheless, these tasks may be removable by automation and perceived as occupational inefficiencies to people not directly involved. As such, mixed changes to the quality of work and life are not limited to a single type of job. Echoing Wiener's earlier speculations, we see how workers engaged in white-collar, blue-collar, routine, cognitive, manual, creative, or social-emotional work may all experience unanticipated and undesirable transformation unless the more intrinsically valuable aspects of their working conditions are actively preserved or fostered.

Thus, the idea that advanced automation makes creative arts more efficient, productive, or net beneficial by some metrics does not entail that it preserves significant qualitative aspects of the work required to produce art. This is true for both the workers who experience these changes directly and for those around them—their clients, their students, their co-workers. One workshop participant cited a demo of a new AI-assisted co-pilot from a major technology company, during which they were assured that they would "never have to stare at a blank page" again. But this ostensible increase to productivity comes at a (potential) cost, including the enjoyment of creative problem-solving, the experience of growth through struggle, or perhaps the sense that one's work is part of an essential humanity rather than merely an economic output to be optimized. After all, we are human beings, not merely human resources. It may be the case that efficiency helps us better achieve some of our goals as a society, but efficiency is a means, not the goal itself, something we must continually remind ourselves to not lose track of lest we supplant our ethics and dreams with expediency [85].

It is true that critics (even before Wiener!) have warned about the harms of now-established technologies: the Internet, radio, the printing press, and even writing itself (see Socrates in Phaedrus) [86]. And it is true that society has developed new modalities of work and leisure in the aftermath of technological and industrial transitions. But at this point, it would be disingenuous to dismiss the known and predicted harms that have resulted from novel technologies: qualitative changes in the composition of tasks that comprise occupations, declines in social capital, addiction to social media, ever increasing dissemination of misinformation and hate speech, and other damages to the social fabric [87]. While increased productivity through AI may indeed increase the accessibility of the outcomes of complex knowledge-work, allowing many individuals to access healthcare information, translation services, or artistic tools, it might also cheapen the significance of the art, the perceived value of a letter from a constituent to their political representative, the relationships between students and teachers, and more [88], [89]. The mere proliferation of items once thought of as creative or intellectual outputs (such as lectures, photographs, news posts, artworks, conversations, models, and toys) is not the same thing as a sincere and non-alienated enjoyment of the process of producing or engaging with them. Thus, workshop participants warned that we need to be aware of qualitative losses, and that it is essential to exert our agency as individuals and decision-makers [90] to transform work and life in ways that preserve valuable qualitative textures of experience.

VI. Proceedings Part II: Meaningfulness of Work

You can only become truly accomplished at something you love. Don't make money your goal. Instead pursue the things you love doing and then do them so well that people can't take their eyes off of you. — Maya Angelou [91]

A. What Is "Meaningful" Work?

Work is an integral part of what it means to be human. "Meaningful work" is therefore inherently a complex and perhaps messy concept [92]. It is tied to our sense of self, our choices in life, how we flourish or flounder. It is an essential part of how we give meaning to our daily lives and, owing in part to the portion of life spent on work, even to our legacy. Opportunities to express creativity in the choice of tasks that one performs, in one's approach to those tasks, and even the opportunity to "fail" at a project or approach are necessary growth experiences. Meaningful work, expansively understood, is a necessary element of life for humans as occupational, social, and cultural beings, and it must continue to be available in any possible technological future [93]. Likewise, our discussions of the meaning of work also acknowledge the meaningfulness of rest and of activities such as study, sport, spiritual and religious activities, community work, parenthood, cultivating the natural environment, and investing in societies beyond the household level. Hence, the structure and meaningfulness of work exist alongside (and are indispensable for enabling) the meaningfulness of leisure, connection, and sociality outside of work; this time for participating in things outside work is increasingly threatened by jobs that demand arguably greater than 100% devotion [94], [95].

21CW2023 workshop discussions highlighted how technological change can threaten humanity's ability to retain meaningful work. Indeed, without paying deliberate attention to this topic, we doubt that future AI developments will ensure widespread continuity of opportunities for meaningful work and its associated benefits. Existing and historical social trends

already give us reason to fear specific risks or challenges related to automation technologies that would not act in the direction of improving or even safeguarding meaningful work for anyone but the most elite layer of society [96], [97]. Take, for example, the observation that AI bots assist humans by relieving them of "drudgery" (a sentiment whose validity has been challenged in various contexts, such as in situations where AI requires humans to do the tedious, "unskilled" tasks that AI cannot yet accomplish [98] or creates a new underclass responsible for the hidden labor that enables AI [99]). This notion reveals an underlying assumption that the remaining work is of a higher cognitive, more brain taxing (and therefore valuable), content. This observation in itself should prompt us to consider what the impact of such cognitive pressure might be on an individual's overall mental health and general well-being [78], [100].

B. Risks to the Continuity of (Meaningful) Work

Enabling meaningful work for as many people as possible is not usually (or even often) guaranteed to be a key basis for technological decision-making. Indeed, given that "improving productivity" is frequently the central strategic aim that steers design choices for the future of work, profound risks exist for the safeguarding much less the advancement of human well-being through occupational labor. Economic productivity, after all, can coexist with decreasing participation or diminished inclusivity as well as qualitative degradation of everyday experiences [75].

Across all industrial sectors and types of work, massive uncertainties about these issues persist. How do we design human careers at our current technological moment? How do we adjust our educational institutions to support the development of humans that work with AI systems? Which skills do we emphasize, and which can be safely abandoned? How could near-continuous re-skilling or up-skilling be conceived of realistically to ensure that human careers and expertise as well as labor markets are maintained in a cost-effective manner, while also ensuring that a significant majority of human efforts remain engaged in meaningful work? Let us assume here that meaningful work is a human right. What are the technological (or governance, or social, or educational) strategies we need to pursue in the development of AI-enhanced work to foster a universal model for meaningful work? Can we go a step further and prioritize the well-being of those involved in tech-adjacent work, as well? Answering these questions is as essential as it is overwhelming, and yet efforts remain paltry in light of the relentless pace of technological and economic change.

As pointed out already, we do not expect that technological strategies alone will suffice to fully answer these questions or achieve these goals. Indeed, our single-minded preoccupation with the pursuit of productivity may belie the conclusion that sub-optimal productivity is optimal for society, as a whole. Rather than pursuing productivity above all, we need to explicitly recognize human well-being as a necessary conceptual pillar in the automation development journey [101] and position meaningful work as a human right no matter the potential profit of "innovative" technological progress. Certainly, improved economic productivity cannot be the sole guiding pole star of our reasoning [102]. But what then can take its place? What do we agree on as the (multifaceted) goal(s) to optimize for or determine which tasks and forms of work are considered worth preserving, versus those which can be removed from the human sphere? In this context, we also recognize that even if and when meaningful work and well-being are considered desirable, it is unclear how to cast "well-being" and "meaningful work"—integral elements of our individuality—as concrete, measurable concepts in a "data world." How then do we define, measure, and track changes to these desirable goals [103], [104], [105], and justify them in the boardroom and halls of government?

Building on the previous section, we are concerned that as "work" changes along with technological developments, decision-makers in policy, business, technology, and even education will overlook social harms or fail to respond to them in substantive fashion. Some of these harms relate to concrete, quantifiable forms of exclusion, while others are about more qualitative changes, such as what kind of tasks are included in jobs affected by technological advancement and automation, and thereby, the meaningfulness of the work that remains.

C. Exclusion From Work

Current developments in AI are threatening knowledge workers in new ways. People who hold the types of white-collar jobs that previously were considered "immune" to a technologically induced loss of work are now finding themselves in similar positions to the blue-collar workers of Wiener's day [106]. Although there is discourse about creating new jobs through technological change, workshop participants commented multiple times that we hear far less discussion of how to ensure that said new jobs will go to those who have already been made vulnerable [17], rather than people who have been designated as winners, or even to robotic employees [107] judged more suitable for a new job from its first day of existence onwards.

In prior and ongoing processes of industrial change, we have seen a remarkable level of social comfort with recognizing winners and losers and then feeling excited rather than guilty about participating in the kinds of selection processes (and inevitable binary thinking) that differentiate them [108]. We must therefore also challenge and change the ongoing social comfort with processes of exclusion and exclusivity that produce so much precarity and anxiety, and the celebration of institutions that rely upon and intensify these disparities. Otherwise, ingrained socio-political tendencies towards repeated rounds of selection and expulsion from various workforces and communities are likely to overshadow AI's effects on the availability of meaningful work. Without a deliberate revision of attitudes and practices, there is a risk that the development of automation will continue to actively exclude certain members of society and social groups from opportunities for meaningful work and social participation, leading to a wide variety of pathologies [109], [110], [111].

Meanwhile, observably, working lives are getting longer [112]. The fact that we have longer working lives amidst rapid industrial change only heightens the need to re-skill and "up-skill" employees to ensure they can apply for and access forms of work that will offer a sense of attainment through creativity, comfort, and satisfaction. Thus, those who make decisions about employee education need to be person-centered. This includes thinking about what people want in their employment: do they desire to change what they do, or not? Do they want to use automated agents to find or perform their jobs, or not? Do they desire a variety of changing and complementary "gigs," or not? Ultimately, what serves as the motivation in any particular workplace or for our workforce as a whole? It is hard to think about and plan for the future of work in an age of automation or digitization in a way that not only takes action to counteract obvious harms but also works reflexively to consider invisible ones.

At a minimum, we imagine that desired options for re-skilling and growth, and impacts of career and task change, need to be conceptualized and made available to people in advance of when they will need to make the choice about a career change. The burdens of adaptation and adaptability cannot fall entirely upon the individual worker. Indeed, participants in 21CW2023 approached the question of "re-skilling" ambivalently, recognizing its potential necessity for both individuals and societies, while also hesitating and noting that it could serve to transfer additional responsibilities onto the shoulders of those least prepared to accept them [113]. Those that provide and benefit from employment should shoulder the responsibility of placing people in fulfilling jobs for the present as well as truly preparing them for the future.

D. Risks to Meaningfulness

As automation technologies are taking on more cognitive labor, the supervisory tasks that remain for humans in controlling, using, enabling, and integrating AI outputs may become more demanding and complex. The form of "knowledge" that AI offers is relentlessly limited, and it may have little or nothing to do with understanding, judgment, creativity, novelty, or wisdom. Consequently, giving AI "knowledge level" tasks may simultaneously re-task the human workers surrounding it with a responsibility to identify and compensate for new types of errors and infelicities [114]. It is possible to see this notion of "collaboration with AI" optimistically *and* pessimistically. Optimistically, "layers" of AI within the software interfaces of any given workplace could help compensate for the cognitive overload that workers may experience, while also removing the need for them to engage in certain mundane tasks (though the optimal ratio of these tasks is itself unknown). As the resulting knowledge-worker roles start to encompass this complexity, perhaps some will see their evolving work as "interesting." However, others may no longer be satisfied. People pursuing artistic and creative tasks will likely continue to value their status as participants in embodied worlds in ways that stand in stark opposition to, for instance, being a manager of software technologies [115], [116]. The question remains: how do we positively develop the human aspects of work beyond mere compliance with the unexamined postures that technology seems to demand of us?

Responding to Pearl's presentation with particular enthusiasm (see Appendix A in the supplementary material for details), 21CW2023 participants addressed the theme of "failure" and the risk that qualitative changes in work seek to abolish it, thereby impoverishing human experience and impeding the learning process. Reflection on experiences that could be considered "failure" in artistic processes reveals that, quoting Jacqueline Mabey, "To embrace failure, in all its forms, is to desire another kind of world" [117, p. 19]. This framing suggests the quintessential importance of feeling, desiring, and remaining alert/alive to outcomes and even accidents that lead to unforeseen solutions—that arguably only natural, random forces can bring about. Qualitative tasks in the AI-enabled workplace that involve a sense of productive failure, or a critical oscillation between imagination and intention, appear for the present beyond the scope of automation. Machines cannot have a subjective human experience of faltering and failing to produce something imagined and desired, which pivots on readjusting amidst critical feedback while keeping the sense of lack alive (for an exploration of the ways in which humans perceive computing systems to act in "original and creative" ways, see [118]). Machines are not motivated by the potentialities created by an experience of failure. The intention to remove failure in the name of productivity reflects a failure of imagination and thus a failure to understand important dynamics in how humans experience and derive meaning from creative work.

E. Interdisciplinary Illumination, Ongoing Vigilance

It can feel hard to imagine how AI and automation can be put into service not only for the monetary aspects of our economy but also for enabling well-being in the workplace. Developers must be thoughtful about which qualities of workplace experience should be automated away versus retained and amplified. And they also should be cognizant of where and how humans can intervene to validate, audit, and review the automated deliverables. Ultimately, to affirm the importance of "meaningful work" in an inclusive way, the concept must be treated expansively, allowing for culturally diverse, even individual meanings, nuances, and resonances. Due to the diverse and multiple meanings of work, it is important to think and plan in an interdisciplinary manner, deliberately bringing together disparate views that conceptualize a wholistic future of work. Be it technologic, humanistic, economic, philosophical, or legal, no single discipline's view can illuminate the subject matter by itself; instead, diverse perspectives (and voices) can all illuminate it jointly. To take just one paired example from the 21CW2023 presentations, participants were able to consider the divergent workplace experiences at Infosys Corporation, as seen through the expertise of Human Capital (Arohi), alongside, and in comparison, to the ludic and chance-based artistic studio practice of Marcel Duchamp, as seen through expertise in Media and Design (Pearl). Although both presenters imagine working subjects in relations of feedback

with their environment, different imaginations existed for the way in which those subjects could "make themselves relevant."

As Wiener wrote, the impacts of automation projects are unpredictable and to some extent unknowable in advance—they can be used for "good or evil" [50, p. 27]. Ongoing vigilance is necessary to identify the "systemic edge" where jobs may be lost or degraded in ways that elude observation and where existing or potential workers may become "invisibilized" to mainstream political and economic reasoning. The intellectual labor at hand includes constant efforts to identify the ever-changing boundaries of impact and meaning across all of society—not only on work but also on how we all live, and how technology is changing our social systems and relationships [119]. Given the diverse effects that technological change can have on the availability of work and on its qualitative dimensions as well as on the stories we tell ourselves about the relationship between our work and the other aspects of our identities, we need to think about what counts as a society-wide good or bad possible impact. Do we believe that technological change can be construed as part of efficiency gains and orthogonal to questions of existential significance? If not, when are the detriments of technological change so severe (or uncertain) that they require intervention, supervision, and regulation? Are the natural forces of trust, ethics, and compassion in society sufficient to guide our choices towards a "better" society, one that is more inclusive and provides more well-being and meaning for all? If not, how can we change course?

VII. Proceedings Part III: The Limits of Predictability

One interesting change that has taken place is that … chance has been admitted, not merely as a mathematical tool for physics, but as part of its warp and weft. [Here we see a] recognition of an element of incomplete determinism, almost an irrationality in the world … a fundamental element of chance in the texture of the universe itself…

– Norbert Wiener [52, p. 11]

A. Obvious Uncertainty (and the Desire to Overcome It)

The very existence of the workshop on the "future of work in the age of automation" is an expression of the uncertainty we experience when approaching this subject. Any discussion about the future of work is about understanding trends and exploring possibilities to bring some order by elucidating the most likely scenarios given the socio-economic forces in play. The timing of this particular workshop emerged from our perception that the space of feasible scenarios has suddenly and explosively expanded thanks to the introduction of phenomena such as generative large language models in the AI toolkit. Moreover, as AI tools are becoming more democratically accessible and the required computing resides in the seemingly ever-available cloud (this apparent ubiquity is, of course, only available within certain geographic and socio-economic contexts), we are at a junction in time where it appears that any workflow may be affected.

As one such example of uncertainty in this context, we can observe that the present desire to ensure the ubiquity of AI tools comes at a considerable cost to the environment [120], [121]. After all, the augmentation of work through automation and AI-enabled bots requires a large computational and communication infrastructure with concomitant energy, water, mineral, and otherwise land-dependent factors [122], [123], [124], with subsequent geopolitical and other destabilizing implications. This fact deserves more scrutiny, especially given that in present discussions of the human aspects of work, i.e., the "human-in-the-loop," it is often assumed—as discussed earlier—that the economic costs of automation are sufficiently captured through the lens of direct labor productivity outcomes in one's workplace. The perceived uncertainty, combined with the complexity of what the future of work might look like, makes for a risky decision environment. When faced with this type of environment, simplicity and order would presumably be preferred, but it is unclear they can be sustained. It therefore behooves us to explore the limits of predictability of the future of work to chart a course.

In the 1950s, Wiener brought to this discussion his formidable insight as a mathematician, philosopher, and engineer exploring the necessity of feedback (information that loops back on itself) to achieve a desired outcome, whether for an engineered machine, a living cell, or indeed a whole society. His paradigm, *purpose requires adequate information* [52], summarizes his insights well and is particularly relevant in our context. If we want to guarantee a future of work where the meaning of work is preserved for every worker and the well-being of workers is ensured, we will need to avail ourselves of sufficient information—and information that is sufficiently attuned to issues of ethics and equity (see, for example, [19], [125])—to realize this goal. This much is clear from our discussion so far: leaving the future of work to be governed by mere productivity arguments will by no means guarantee the desired outcomes.

Recalling the earlier section on Wiener's writing, it is helpful to note that Wiener saw the replacement of the drudgery of work as inevitable, indeed desirable from many perspectives. Even so, he worried about the negative consequences associated with the displacement of human work, if the sole motive for the latter was simply "because we can." Moreover, because the social-industrial system he observed was not set up to enable a transition in work that didn't spell widespread disaster for society, he walked away from opportunities to assist corporate entities in their objective to automate. Instead, as discussed above, he actively sought to persuade others to provide a balance of power against mere automation by focusing on the well-being of the worker [48].

Let us point out that human work, the *essence* of human work, is not the primary focus in studies that emerge from engineering, mathematics, or AI disciplines. In the physical sciences, work is nearly synonymous with energy, as in lifting a weight over a certain distance, which can be measured precisely and is expressed in Joules. Work is further characterized with concepts such as entropy, free energy, time and motion complexity, and ergonomics, to name a few aspects

that are readily measured and studied. Scholars who are situated in the computer world consider the number of bits needed to formulate a (computational) problem and count how many elementary computer operations are required to achieve an outcome (that is, to complete a computational task). All these ideas describe the physically observable and quantifiable aspects of work. They are equally relevant when humans perform the work in question, or when it is done by machine.

However, these physical and computational measures do not capture more intangible factors, such as human well-being or meaning derived from work, for which the complexity of subjective and objective measurement renders consensus difficult [103], [126], [127]. Whereas the well-being of a machine may be captured by simple observations about its fit for purpose and ability to repeat the same task without error, human well-being is much more complex, and it is dependent not only on the work at hand but also on the whole environment within which the human operates, including often-contested social and political contexts. These types of constraints come into stark view when people with a diversity of perspectives gather to deliberate on the notion of human work, even in the case of shared interests.

B. What Do We Not Know?

Wiener's paradigm that purpose requires adequate information indicates that to understand the future of work we ought to start with understanding the purpose of the process of change. Indeed, the displacement of work itself requires a purpose and the act of displacing work must serve a human and/or societal purpose. Why do we displace work? Why do we choose to displace work?

Sometimes we displace work just because we can, to make a point. In many cases, the work done by a machine, being fit for purpose, is perceived to be cheaper and more time effective; more consistent, safe, and reliable; and most importantly, largely independent of the availability of human labor. Perceived or real skill shortage serves as one of the strongest motivating forces to pursue automation (e.g., think of driverless mining trucks [128] or robots in rehabilitation and elderly care [129]). Indeed, the moment we automate a task that task becomes the *mere* consequence of infrastructure (hardware and software), the costs of which are reflected in the *depreciation* ledger in the accounts, a socially derived feature that is so unlike human work. The future of that task is now the subject of engineering (hardware and software maintenance and revisions) and management in terms of business planning and monitoring. Presently, of course, tasks are often not completely automated insofar as there remains human oversight. Yet, this oversight often requires an additional level of cognition to manage the automated task itself, and the automation process therefore often drives demand for people with higher skills, greater cognitive ability, and enhanced stress resilience [130].

In this scenario, tasks performed by automation are subject to a different form of task degradation, i.e., no longer are human stress, attention lapse, or sickness alone to blame for task performance degradation, but rather cyber-incidents, wear and tear, AI model degradation, and hardware and software failures along the AI lifecycle equally play a role. This also leads to new requirements for human oversight and human agency in that task automation creates new work streams through the supply chain of services in the design, implementation, and subsequent maintenance and governance of automated tasks.

Do we truly understand the consequences of this displacement process? And, relatedly, do we actually have sufficient information to achieve the purpose of meaningful work and well-being for all human workers? Indeed, abstractly speaking, any one task is but a link in a series of related tasks, and such processes are but components of complex interconnections of processes across organizations and our society more broadly. Given this interconnectivity, does it logically follow that by iterating the automation process one task or job at a time that we can end up with replacing all work of all humans, thus defeating our initial purpose of retaining meaningful work? Or is the human work in the supply and supervision of automation services (e.g., to conceive, develop, implement, supervise, maintain, and replace) rich enough to have a never-ending story for human and humanly meaningful work? Are we not going to—as Wiener put it—hit the "limitations" of human cognitive ability and discover forms of automation we are unable to supervise [49, p. 69], [131]? Could it be that we succumb to being governed by machines of our own creation?

Let us immediately temper such longer-term considerations by clearly stating that machines are also subject to capacity limits. Even though we may not fully understand what these limits are [132], [133], [134], they do exist [135], and these limits will determine the complexity of the tasks that can be automated, in turn limiting what the iterative process of automation can achieve. Instead, as it was pointed out in the workshop (and in an echo of Wiener's formulations), perhaps more sobering is that the intent to displace work (today, yesterday, and tomorrow) does not have to be ethical. It is entirely conceivable, however unethical, that some may choose not to limit themselves to the displacement of human work under the imposed restrictions of preserving basic human rights, meaningful work, or well-being for all. In fact, such a disposition seems evident and dominant. The proliferation of misinformation in online spaces, the addictive nature of some social platforms, and the present use of drones in warfare offer glimpses of what is being pursued and what dystopian futures may become reality [136].

To combat these possibilities, proper governance—based on principles that receive broad societal acceptance and founded on clear accountability mechanisms—of all people, organizations, and processes that shape the future of work is essential (for a related argument, see [116]). Some fear that governance may be too slow, and others believe it may stop society from reaping the benefits of displacing work through automation; nonetheless, it is our thesis that proper governance with appropriate, meaningful consequences for breaking agreed conventions provides the only realistic way forward to minimize the unsavory and (un)intended consequences of automation on the future of work. Allowing chaos or the invisible hand alone to rule will not provide the environment

to proceed with confidence nor create the trust required to adopt new and more positive ways of working and being.

C. When Is Limited Information Adequate?

We accept that we may not be able to predict the future of work clearly. Nevertheless, we believe that through governance we may chart a path that avoids unacceptable futures and achieves the social license that automation requires to operate effectively and more so with credible trustworthiness.

Moreover, there is further reason to be somewhat optimistic, independent of governance, in that the limitations of AI technology are far more significant than many proponents proclaim. Indeed, the power and the limitation of AI (as we know it) is that it depends on data, and more importantly, on reliable, well-curated, fit-for-purpose data. In the case of task automation, the data have to declare the task properties in detail under nearly all conceivable circumstances, a charge rendered problematic by the constant edge cases, trade-offs, and sheer difficulty of extracting tacit and implicit knowledge [134], [137]. Our assurance stems from the belief and hard-learnt experience that most data environments fall well short of this ideal, especially as past data fall behind present and future evolving needs. To wit, by definition, data are scarce when it comes to rarely seen circumstances. This fact, combined with the statistical nature of AI, constrains AI-based automation to those tasks where reliable data are available. Allowing AI to venture beyond the data, either by interpolation or extrapolation, is common; however, left unchecked, it is well known to lead to so called AI "hallucinations," abstraction failures, biases, and to otherwise prove inadequate [138], [139], [140]. It follows that, apart from the simplest, most mundane tasks, only those parts of a task can be automated where adequate data live, requiring human intervention to make a judgement in all other circumstances. The optimism is thus that AI-driven automation is limited to augmenting human task execution for the bulk of tasks, such that its failings can be monitored. Another skill the human supervisor needs to master!

On the flip side, all tasks where we can observe and measure "adequately," that is, describe in nearly every aspect how to arrive at a satisfactory outcome, can be meaningfully automated using present day AI tools. This collection of tasks is demonstrably not negligible, as we already see displacement of work occurring in past and present automation waves [141], [142]. Even the limited capacity of present AI can be amplified and leveraged by human ingenuity to great advantage, sometimes by taking shortcuts even when AI capabilities are insufficient for the task [143].

We are deliberately being vague in what "adequately" actually means in this context. Indeed, even a simple task is rarely isolated but rather forms part of a larger web of tasks and dynamic feedback loops. The presence of feedback loops makes it extremely hard to describe the notion of "adequate" information, so much so that the automation of a simple task that forms part of a large web of tasks may still lead to rather unexpected consequences in the same way that the flapping of the wings of the proverbial butterfly in the Amazon effects the path of a storm across the Bay of Mexico. Vice versa, strong feedback loops may negate some of the unwanted or uncalled for local, single-task responses, by reducing their amplitude and thus their aggregate effect on the end-to-end behavior of the process. Proper governance, through overarching policy strategy, is one such feedback loop.

The problem of information within feedback loops was well known to Wiener, who saw the ultimate impacts of automation projects as unpredictable and to some extent unknowable in advance. To elaborate, it is perhaps useful to quote Einstein's *Science and Religion* (1941):

> When the number of factors coming into play in a phenomenological complex is too large, scientific method in most cases fails us. One need only think of the weather, in which case prediction even for a few days ahead is impossible. Nevertheless no one doubts that we are confronted with a causal connection whose causal components are in the main known to us. Occurrences in this domain are beyond the reach of exact prediction because of the variety of factors in operation, not because of any lack of order in nature [144, p. 47].

Einstein's observation is about an instance in nature where we lack predictability despite an incredible amount of order and determinism through the natural laws to which nature appears to be subject. This idea was already announced by Poincaré [145], and today we call this phenomenon of unpredictability despite determinism *chaos* [146].

In the automation of work context, we deal with human endeavors that cut across multiple levels, inherently exhibit a lack of order, and manifest a profound non-determinism. *It is thus appropriate to accept the future of work, even a governed future, to be uncertain and unknowable*. Nevertheless, this conclusion does not alleviate the need for careful forecasting and planning. Indeed, our expectation is that the stronger and more universal the governance of automation, and the better the associated information flow, the more assurance we will have that the future of work respects the well-being and meaning of work.

VIII. Proceedings Part IV: Opportunities for Incorporating Values and Agency

Can AI positively impact society and foster development despite the risks it poses to humanity's future? There is room for qualified optimism, if these tools can be deployed towards human values in ways that foster agency and minimize inequality.

A. Unequal Distribution of Benefits and Harms

We freely admit that a large portion of the 21CW2023 workshop discussions foregrounded pessimistic views. The unequal impacts of automation and technological innovation are widespread: immediate benefits from AI are typically consolidated by in the hands of an elite and powerful few, while risks are decentralized among society, leading to a staggered distribution of benefits and harms [147], [148]. Moreover, AI is poised to disrupt current working conditions

by entrenching existing incentives and resource distributions that have already warped our present state of work. Take, for example, the dependence of AI companies on "ghost workers" whose hidden labor is essential for training AI and for identifying and correcting AI's missteps [98], [99], [149]. The subordinate, poorly remunerated work these individuals perform to support AI is exactly the kind of thing that Wiener feared.

Within these types of labor ecosystems, precarious employment has intensified income and wealth inequality and decreased access to social support systems, which in turn heightens dependency on that precarious employment [79]. These dynamics were a focus of Reynolds's presentation, which explored salary and time outcomes in the transition to (often algorithmically-mediated) gig work; because gig workers are typically classified as independent contractors rather than employees, they often lack the fringe benefits and workplace protections that come with conventional work arrangements, such as minimum wage, overtime pay, workers' compensation, sick leave, parental leave, health and safety protections, the right to unionize, and protection from discrimination and harassment [150]. Relatedly, Schiff's remarks highlighted the gulf between management techniques used to motivate white-collar workers (for example, Herzberg's two-factor theory of motivation [151]) and the real working conditions for laborers in many manufacturing settings worldwide. These differential impacts of AI and treatment of classes of laborers underscored the ways that current incentive structures and allocation of resources (including, as James's presentation explored, within higher education) yield wildly different socioeconomic results. Due to the inequality baked into these systems, any robust assessment of AI innovation—its risks as well as its benefits—becomes daunting; it requires nuanced analysis that can account for multiple factors and consequences across varied communities and contexts.

B. Redefining Value and Labor

Despite these sobering observations, workshop discussions oscillated between a focus on negative consequences and opportunities for positive effects. AI can displace workers, but it can also be used to re-skill and up-skill them to better adapt to changes in the workplace due to advancing AI automation. Indeed, AI has already been used to develop bandwidth and capacity in underserved professions and public services, such as healthcare [152], [153]. Understood in this way, many of the aspects of AI innovation that pose unprecedented risks to human values also present unique potential to promote human flourishing.

Our engagement with these questions resonated strongly with Wiener's formulation—that ethical socio-technical systems are more likely to emerge within "a society based on human values other than buying and selling" [50, p. 28]. The group discussion consistently stressed the need to move away from an economy centered on the production of profit towards one that foregrounds humane values. As individual presentations illustrated, this ambition can be advanced in sectors as varied as: the fine arts (as evidenced in Pearl's discussion of failure as a constitutive force in several avant-garde artists' work); agriculture (as in the work that Camaréna has undertaken to mobilize new technologies to benefit small-scale farming projects in Australia); government (as in Kaevats's overview of public-sector-run application initiatives in Estonia); and industry (as in the approaches to employee training practices at India's Infosys corporation, which Arohi shared).

Across these diverse domains, it becomes clear that economic measures of success are inadequate for mapping the consequences of automation's effects on labor. Instead, concepts rooted in guaranteeing universal well-being and fulfillment need to be part of the conversation. These include frameworks such as "Mental Wealth" (a key term in Buchanan's presentation), Universal Basic Income (UBI, central to Schmitt's remarks), or Universal Basic Flourishing. And, as Lajoie's presentation emphasized, returning to the concept of "governance" (discussed in the previous section), it would be ideal if recognition of these "well-being"-focused criteria could be coupled with policy instruments to amplify public values and agency. This is an admittedly challenging goal, for numerous reasons: concerns about government overreach and innovation disruption [154], [155]; the oversized influence of corporate interests within some government contexts [156], [157], [158], [159], [160]; the more pedestrian fact that most regulators and lawmakers lack technical expertise to keep pace with the rapidly evolving complexities of AI [161]. And indeed, although reasonably precautionary regulation and enforcement policies have been implemented in the European Union [162], [163], in the United States, pro-innovation legislation and perspectives dominate [159], and risk-management frameworks typically remain voluntary [164]. Despite persistent challenges, however, we see potential for the figurative window opened by AI to allow social and political movements to glimpse and embrace a more comprehensive theory of value.

C. Creative Problem-Solving Through Interdisciplinary Collaboration

Using Wiener's warnings to navigate these dynamics steered workshop discussions towards the need for humans to remain at the helm of AI innovation as well as the importance of fostering design research and practice that brings together diverse disciplines, people, and technologies in the face of wicked problems [165]. The engineering and computing communities have a crucial role to play in contributing their technical expertise to the overall automation/labor problem-framing conversation, where rationalistic and design thinking processes can be embraced for the purpose of values-aligned problem-solving and solution design [166]. At the same time, however, solutions must also extend beyond the engineering community. As observed by scholars (e.g., [167], [168]), a narrow focus on engineers to the exclusion of business leaders, policymakers, and other decision-makers can mask the layers of agency and accountability required to advance AI and other emergent technologies responsibly. In addition, collaboration with scholars from the humanities and social sciences is

needed both within and beyond tech firms to qualitatively and rhetorically assess impacts and to ensure a balanced perspective on AI innovation.

This type of interdisciplinary collaboration can prompt those who design and develop technologies, and those who shape the conditions of their agency and limits, to become more adept at defining and declaring their intent as well as taking responsibility to reassess their intentions when they do not match outcomes. Ideally, when people from different backgrounds (disciplinary, geographic, economic, etc.) work together to face these issues—when they engage in the types of processes that underlie many participatory and inclusive design frameworks [169], [170], [171]—they will be able to better develop innovative, creative, and ethical strategies for resolving disparities and reaching equitable solutions.

On this note, to ensure a human-centered approach in maximizing the capabilities of AI for societal benefit, we need to broaden the scope of individuals who can participate and contribute effectively [172], [173]. Regardless of the direction AI innovation might take, there was consensus that we must think critically and inclusively about who gets to wield authority in this sector. Only by striving for more expansive forms of collaboration, collective action, and solidarity can we ensure that the value and meaningfulness of traditionally marginalized domains of work—such as elderly care, child care, homekeeping, community engagement, and media labor [174], [175], [176]—will be recognized, valued, and supported. Since everyone has a stake in the future, charting an ethical path forward will depend upon empowering a wider range of stakeholders to assess how innovation affects their livelihoods and enabling them to actively shape their role in the future of work.

IX. Conclusion and Next Steps

In closing, and in returning to a key premise of the 21CW2023 workshop, we see value in bringing together scholars and practitioners from multiple backgrounds to discuss, debate, and move forward on these topics. This type of collaborative effort, directed towards tangible future outcomes (whether that means educating students, drafting policy, working with small-scale agricultural producers, developing company training programs, creating open-access repositories within public-sector spaces, etc.) is where we locate our optimism. In addition, we encourage technologists and the broader community of scholars who study technology's effects on the world to adopt historically attuned perspectives. We have much to learn from writers and thinkers from the past, such as Wiener and his contemporaries, given that their work grapples with similar questions and challenges to those we face during our own, later, period of rapid technological change.

Our argument here echoes and builds from the calls to center issues like trust, dignity, empathy, and sustainability in analyses and recommendations regarding the future of work, raised by participants at the 21CW2021 conference [42]; we anticipate that these discussions will continue at future iterations of the 21CW series, the next of which takes place in May 2025 in Matsue, Japan. For now, we hope that this modest—and inevitably incomplete—synthesis of the 21CW2023 workshop generates additional reflection and input from readers of *IEEE Transactions on Technology and Society*. We invite opportunities for continued conversation and cross-disciplinary pollination of ideas, warnings, hopes, speculation, and critique related to both "the future of work in the age of automation" and the legacy of Wiener's contributions in the twenty-first century.

X. Key Takeaways

To consolidate the central through-lines from the sections above, we offer to readers the following set of "key takeaways" and "key terms." We hope that this abbreviated version of the workshop findings will provide a useful starting point for further reflection, research, solidarity, and action.

A. Part I: Qualitative and Quantitative Losses

*Public and policy discourse is loaded with assumptions or incomplete dichotomies. We can identify them, unpack them, and challenge them as we probe into how the future of work is being thought about and identify implications that are being neglected.

*The future of work discourse is about economic systems, but we are humans, not just economic inputs and outputs. By solely focusing on productivity, we ignore important things like *meaning* that can be generated by doing work we enjoy, fostering interpersonal relationships, and placing value on the texture of experience itself.

*We need to re-evaluate our success criteria. If we only pay attention to net benefits, we neglect harms and trade-offs that must be part of decision-making within a pluralistic society.

Key Terms: disruption, texture, assumptions, experience, relationships, trade-offs

B. Part II: Meaningfulness of Work

*The mere optimization of productivity does not preserve the property of meaningfulness in work, nor does it ensure the well-being of the worker.

*The properties of "meaningful" and "well-being" in work are difficult to quantify which hinders their use in objective, data driven decisions for the future development of work.

*Deliberate attention is needed to ensure that future AI developments do not endanger the widespread continuity of meaningful work and well-being of the worker.

Key Terms: well-being, meaningful work, data-driven, winners-losers, uncertainty

C. Part III: The Limits of Predictability

*Because the space of "future work" encompasses such an enormous range of possibilities, both utopian and dystopian futures appear equally feasible.

*Order in chaos, if it exists at all, is a property that emerges from the dynamic forces at play, and not a property that is inherently predictable.

*Governance of automation is key to preserve the meaning of work and the well-being of workers. However, governance does not render the future of work entirely predictable.

Key Terms: uncertainty, unpredictability, non-determinism, chaos, governance

D. Part IV: Opportunities for Incorporating Values and Agency

*The benefits of AI are often consolidated by owners, while risks are distributed across society. This inequality must be accounted for in robust assessment frameworks of AI's impact.

*The reformulation of human potential offered by AI also affords opportunities to rethink metrics for value, productivity, and work towards systems that center inclusion rather than profit.

*Assessing the technical and philosophical complexities of AI is compounded by knowledge gaps among lawmakers and the influence of corporate interests in shaping regulatory frameworks. Making informed AI regulation will require the coordination of diverse stakeholder organizations.

Key Terms: automating inequality, human flourishing, human-centered approach, value redefinition, regulatory challenges

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Heather A. Love and Rebecca Sherlock are with the Department of English Language and Literature, University of Waterloo, Waterloo, ON N2L 3G1, Canada (e-mail: halove@uwaterloo.ca; rebecca.sherlock@uwaterloo.ca).

Greg Adamson is with the School of Population and Global Health, University of Melbourne, Melbourne, VIC 3010, Australia (e-mail: g.adamson@ieee.org).

Mallory James is with the Department of Science, Technology and Society, Technical University of Munich, 80333 Munich, Germany (e-mail: mallory.james@tum.de).

Jason Lajoie resides in Cambridge, MA 02140 USA (e-mail: jlajoie7@gmail.com).

Iven Mareels is with Federation University Australia, Ballarat, VIC 3353, Australia (e-mail: i.mareels@federation.edu.au).

Zach Pearl is with the Department of Art, Media, Performance, and Design, York University, Toronto, ON M3J 1P3, Canada (e-mail: zapearl@yorku.ca).

Daniel S. Schiff is with the Department of Political Science, Purdue University, West Lafayette, IN 47907 USA (e-mail: dschiff@purdue.edu; jeremyr@purdue.edu).

Ketra Schmitt is with the Centre for Engineering in Society (Department for Schmitt), Concordia University, Montreal, QC H3G 1M8, Canada (e-mail: ketra.schmitt@concordia.ca).

Thirumala Arohi and Victor Sundararaj are with Infosys Limited, Bengaluru 560100, India (e-mail: THIRUMALAA@infosys.com; Victor_S@infosys.com).

John Buchanan is with the Business School, University of Sydney, Sydney, NSW 2006, Australia (e-mail: john.buchanan@sydney.edu.au).

Stéphanie Camaréna is with Source Transitions, Melbourne, VIC 3124, Australia (e-mail: stephanie@sourcetransitions.org).

Marten Kaevats is with IEEE City Sherpa, Estonia (e-mail: martenkaevats@gmail.com).

Jeremy Reynolds is with the Department of Sociology, Purdue University, West Lafayette, IN 47907 USA (e-mail: jeremyr@purdue.edu).

Pedro H. Albuquerque is with Aix-Marseille Univ, CNRS, AMSE, 13284 Marseille, France (e-mail: pha@use.startmail.com).

John C. Havens is with IEEE Planet Positive 2030, New York, NY 10016 USA (e-mail: j.c.havens@ieee.org).

Davis Chacón-Hurtado is with the School of Civil and Environmental Engineering, University of Connecticut, Storrs, CT 06269 USA (e-mail: davis.chacon-hurtado@uconn.edu).

Sucheta Lahiri is with the School of Information Studies, Syracuse University, Syracuse, NY 13244 USA (e-mail: sulahiri@syr.edu).

Ayse Ocal is with the Computer Engineering Department, Yildiz Technical University, 34349 Istanbul, Türkiye (e-mail: ayse.dalgali@yildiz.edu.tr).

Alexi Orchard is with the Technology and Digital Studies Program, University of Notre Dame, Notre Dame, IN 46556 USA (e-mail: aorchard@nd.edu).

Michael Rigby resides in Melbourne, VIC 3000, Australia (e-mail: michaelrigby.au@gmail.com).

Qin Zhu is with the Department of Engineering Education, Virginia Tech, Blacksburg, VA 24061 USA (e-mail: qinzhu@vt.edu).

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Heather A. Love (Member, IEEE; Co-Organizer, Presenter, Proceedings Core Author, and overall Proceedings Coordinator for 21CW2023) received the Ph.D. degree in English from Indiana University. She is an Assistant Professor of English with the University of Waterloo, where she conducts interdisciplinary research and teaches courses on topics related to literature, culture, technology, health, and engineering education. She is the author of *Cybernetic Aesthetics: Modernist Networks of Information and Data* (Cambridge University Press, 2023), and her work has appeared in journals such as *Modernism/Modernity*, *New Literary History*, *Medical Humanities*, and *IEEE Technology and Society Magazine* (TSM). In 2024, she received the Brian M. O'Connell SSIT Distinguished Service Award. She is the Editor-in-Chief of the IEEE SSIT Newsletter and an Associate Editor of IEEE TSM.

Greg Adamson (Senior Member, IEEE; Co-Organizer, Presenter, and Proceedings Core Author for 21CW2023) received the Bachelor of Technology degree in engineering from the University of Southern Queensland, the Master Commercial Law degree from Melbourne Law School, and the Ph.D. degree in e-business from RMIT University. He is an Honorary Associate Professor with the University of Melbourne's Nossal Institute for Global Health and a leading Norbert Wiener Scholar. He founded the IEEE Conference Series on Norbert Wiener in the 21st Century and has been leading the initiative for more than ten years. His day job is Chief Information Security Officer with the Victorian Department of Transport and Planning, Australia. A Past-President of IEEE SSIT, he currently serves as a member of the society's Strategic Planning Committee and the Vice President for Technical Activities.

Mallory James (Member, IEEE; Presenter and Proceedings Core Author for 21CW2023) received the Ph.D. degree in anthropology from the University of Chicago, where she investigated dynamics of responsibility in Australian carbon capture and storage engineering. She is an Engineering Studies and Political Economy Researcher, currently working in the role of Postdoctoral Research Associate with the Department of Science, Technology and Society, Technical University of Munich. With colleagues in the Technical University of Munich, she is currently investigating how European scientists construct concepts of "excellence" while applying for early-career scientific research grants.

Jason Lajoie (Presenter and Proceedings Core Author for 21CW2023) received the Ph.D. degree in English from the University of Waterloos and is an early career scholar in responsible innovation, research-creation design and equity, and queer media theory. Jason was the Research Associate for the Council for Responsible Innovation at the University of Waterloo, spearheading research projects related to social justice, equity, and technological stewardship, as well as for Engineering Change Lab, a non-profit that convenes stakeholders from across the engineering community and beyond to address systemic challenges by promoting sustainable and equitable approaches to technology.

Iven Mareels (Life Fellow, IEEE; Co-Organizer, Presenter, and Proceedings Core Author for 21CW2023) received the Master of Engineering degree in electromechanical from Ghent University in 1982, and the Ph.D. degree in systems engineering from Australian National University in 1987. He is a Pro Vice-Chancellor Innovation and the Executive Dean of Federation University Australia. He is also a Director of the Australian Academy of Technological Sciences and Engineering, and a nonexecutive Director of Rubicon Water. Previously, he was with IBM, inter alia as the Director of IBM Research, Australia, from February 2018 to March 2021; and the Dean of Engineering with the University of Melbourne from 2007 to 2018. He is a Commander in the Order of the Crown of Belgium and received the Centenary Medal of Australia for contributions to engineering education and research. He is a Fellow of the Academy of Technological Sciences and Engineering, the International Federation of Automatic Control, and Engineers Australia, a Foreign Fellow of the Royal Flemish Academy of Belgium for Science and the Arts, and an Inaugural Fellow of the Asian Control Association.

Zach Pearl (Presenter and a Proceedings Core Author for 21CW2023) received the MFA degree in criticism and curatorial practice from the Ontario College of Art and Design University in 2012, and the Ph.D. degree in English language and literature from the University of Waterloo in 2023. He continues to teach as an Adjunct Faculty of Integrated Media and Graphic Design with the Ontario College of Art and Design University. He is a writer, a designer, and an educator working at the intersection of art, feminism, and critical media studies. He is currently a Postdoctoral Fellow of Nonprofit Arts Publishing with York University, Toronto/Tkaronto, Canada, and the Managing Editor of PUBLIC Journal (est. 1988) and PUBLIC Books (est. 2007).

Daniel S. Schiff (Member, IEEE; Presenter and Proceedings Core Author for 21CW2023) is an Assistant Professor of Technology Policy and the Co-Director of the Governance and Responsible AI Lab, Purdue University. He studies the formal and informal governance of AI through policy and industry, as well as AI's social and ethical implications in domains like education, labor, misinformation, and criminal justice. You can see his work in venues such as *Policy Studies Journal*, *Public Administration Review*, *Policy and Society*, *American Political Science Review*, *Science and Public Policy*, *Public Administration*, *Technology in Society*, *Review of Policy Research*, *AI & Society*, the *International Journal of AI in Education*, and IEEE TRANSACTIONS ON TECHNOLOGY AND SOCIETY.

Ketra Schmitt (Member, IEEE; Presenter and Proceedings Core Author for 21CW2023) is an Associate Professor with the Centre for Engineering and Society and an Associate Member of the Concordia Institute for Information Systems Engineering, Gina Cody School of Engineering and Computer Science, Concordia University, Montreal, Canada. She is currently the Editor-in-Chief of *IEEE Technology and Society Magazine* and serves as a Board Member for the IEEE Society for the Social Implications of Technology.

Thirumala Arohi (Thiru; Presenter for 21CW2023) is the Executive Vice President and the Head of Education, Training, and Assessment with Infosys Ltd. He drives innovation to empower platform-driven learning interventions to enable future-ready talent within Infosys, client organizations, and societal communities. He anchors the AI-First Live Enterprise charter for AI-First Learning and Change Management. His over-25-year association with Infosys spans a variety of business roles both in India and the USA. His experience in managing software delivery projects across the globe made him a natural choice to transform Infosys education offerings through digital learning platforms and apps to improve educator and learner experience. He serves on the board of I.E Business School, Madrid, and anchors Infosys Springboard, the digital inclusion and learning platform delivering the digital skills to succeed for millions of people and creating an equal digital future for all.

John Buchanan (Presenter at 21CW2023) is currently the Co-Director of the Mental Wealth Initiative and a Professor in the Business Information Systems Discipline with the University of Sydney Business School. His key domain of expertise is labor market structuring and its implications for skills and education. This research involves, inter alia, using data science in conjunction with qualitative methods to generate new scholarly and policy relevant knowledge. His current major research interests are the future of expertise and social solidarity in a world of mass underemployment and AI, and understanding how mental and not just material aspects of life determine national prosperity.

Stéphanie Camaréna (Associate Member, IEEE; Presenter for 21CW2023) is the Founder of Source Transitions, a for-profit for-purpose company leveraging AI for radical transitions to sustainable systems. With 15+ years of cross-sector experience, she designs human-centered solutions for sustainability impact. Her doctoral research with RMIT University explored AI's role in sustainable food systems. She contributes to fields like systems thinking, transdisciplinary research, and interaction design. An award-winning strategist, she drives sustainable innovation through multidisciplinary collaboration. She serves as the Co-Chair of the IEEE Planet Positive Farmlands Committee, a GPAI Expert for the OECD's Scaling Responsible AI Solutions initiative, and a Human-Centered Designer at Our Future Life, establishing herself as a thought leader in responsible AI for positive societal impact.

Marten Kaevats (Member, IEEE; Presenter for 21CW2023) is the IEEE City Sherpa and the Co-Founder of GovStack. He is the former National Digital Advisor in the Government of Estonia or unofficially the Chief Innovation Officer of Estonia. Being responsible for everything digital and innovation in Estonia, he was working on upgrading the interoperability system architecture of his country. The goal of all his work is to build adaptable and future-proof governance architecture, while acknowledging well that predicting that future in its complexity is impossible. Estonia, being a prime example of distributed governance architecture based on human-scale values where every end user is in control of their data, is perfect in testing out new forms of governance suitable for the 21st century.

Jeremy Reynolds (Presenter for 21CW2023) is a Professor of Sociology with Purdue University. His research examines both work-family issues and inequality. He studies the extent to which workers can accommodate personal and family needs by adjusting when, where, and how much they work. Recently, he has focused on gig work schedules and the extent to which they reflect worker preferences. He has published in leading journals, including *American Sociological Review*, *Social Forces*, *Work and Occupations*, *Journal of Marriage and Family*, and *Industrial and Labor Relations Review*. He is a former winner of the Rosabeth Moss Kanter Award.

Pedro H. Albuquerque (Senior Member, IEEE; Participant at 21CW2023) was born in Brazil and lives in France. He received the Bachelor of Electrical Engineering degree from the University of Brasilia, and the Ph.D. degree in economics from the University of Wisconsin–Madison. He is a Research Fellow with the Aix-Marseille School of Economics and a Cofounder of ACCELERATION & ADAPTATION. He has published articles in a large number of scientific journals and has presented at leading international conferences, in fields as varied as occupational science, engineering, economics, finance, and social studies. His areas of interest are technology studies, economics, occupational science, sustainability, and finance.

John C. Havens (Participant at 21CW2023) is the Founding Executive Director of The IEEE Global Initiative on Ethics of Autonomous and Intelligent Systems and the author of *Heartificial Intelligence: Embracing Our Humanity to Maximize Machines*. He is also the Director of the IEEE Planet Positive 2030 Initiative.

Davis Chacón-Hurtado (Participant at 21CW2023) grew up in Cusco, Perú. He received the B.S. degree in civil engineering from the University of San Antonio Abad of Cusco, Cusco, the M.S.C.E. degree from the University of Puerto Rico at Mayagüez, and the Ph.D. degree in transportation and infrastructure systems from Purdue University, West Lafayette, IN, USA, in 2018. He is an Assistant Research Professor with the University of Connecticut (UConn). He co-directs the Engineering for Human Rights Initiative, which is a collaboration between UConn's Office of the Vice Provost for Research, the College of Engineering, and the Human Rights Institute to promote and advance interdisciplinary research in engineering with a clear focus on societal outcomes. He is working with several faculty on campus to develop research and curriculum at the intersection of human rights and engineering. His research interests include transportation equity, human rights, environmental justice, and economic resilience.

Sucheta Lahiri (Participant at 21CW2023) is currently pursuing the Ph.D. degree with the School of Information Studies, Syracuse University. She is a seasoned risk management professional with over 12 years of industry experience in India. Her innovative research explores how data science practitioners from the Global South articulate project-level risks of failure. Her work investigates the complex dynamics through which various social agents legitimize or delegitimize these risks, employing techniques such as persuasion, coercion, and leveraging power imbalances. With a keen eye on fostering a more democratic and inclusive work culture, her research aims to develop a ground-up risk management framework for data science practitioners. This framework seeks to effectively mitigate the risks of data science project failures, thereby enhancing project success rates and promoting equitable practices within the field.

Ayse Ocal (Participant at 21CW2023) received the M.S. degree in information management with a focus on data science and the Ph.D. degree from Syracuse University, Syracuse, NY, USA, in 2018 and 2023, respectively. She is currently working with the Computer Engineering Department, Yildiz Technical University, Istanbul. Her recent research integrates social science with data science tools to advance our understanding of opinions about the future of AI. She uses advanced natural language processing techniques to discern people's opinions, emotions, and expectations on social media. She is the first author on many published journal articles and conference papers, and she has served as the reviewer for many conference and journal papers.

Alexi Orchard (Participant and Workshop Transcription Co-Organizer for 21CW2023) received the Ph.D. degree from the University of Waterloo, where she also managed the Critical Media Lab from 2022 to 2024. She is an Assistant Teaching Professor of Technology and Digital Studies with the University of Notre Dame. Her teaching and research specialties include engineering ethics, responsible innovation, technical communication, and critical and speculative design methods.

Michael Rigby (Member, IEEE; Co-Organizer for 21CW2023) received the Bachelor of Design degree from Monash University, Australia, and the Bachelor of Geomatic Engineering degree (Hons.) and the Ph.D. degree in engineering from The University of Melbourne. He is a Geospatial Specialist and an Independent Scholar working at the intersection of geospatial information, decision support and analysis, and user experience design. His research interests include geographic information science topics of representation, analysis, visualization, and decision making, with a keen eye on cybernetics, the natural environment, and social implications of technology. He has co-organized/presented at 21CW series events in Boston (2014), Melbourne (2016), and Chennai (2020).

Rebecca Sherlock (Participant and a Workshop Transcription Co-Organizer for 21CW2023) is currently pursuing the Ph.D. degree with the University of Waterloo and works as a Design Director in the technology sector. Her research explores the intersection of responsible innovation, critical design, and ethical technology design, with special interest in how these topics are realized within industry. As a member of the University of Waterloo's Critical Media Lab, she engages in research to understand how responsible innovation might be integrated directly into technological design practices.

Victor Sundararaj (Participant at 21CW2023) is the Associate Vice President and the Head of Learning with Infosys Global Geographies, Subsidiaries, and Business Enabling Functions. He leads Engineering and Emerging Technologies competency development initiatives and is a Chief Mentor for Infosys Springboard. He has over two and half decades of experience institutionalizing competency development initiatives at corporate and academic institutions. He is a member of Infosys ETA's Executive Governing Council tasked with the responsibility of institutionalizing framework and strategies for the adoption of technology in Education and Learning. He is part of Board of Studies, Advisory Board, Research Advisory Board, and Governing Council of several institutions in India. He is also a keynote speaker and a panelist in many international workshops and conferences and an active contributor in industry forums, such as SAE, IUCEE, and NASSCOM.

Qin Zhu (Member, IEEE; Participant at 21CW2023) is an Associate Professor with the Department of Engineering Education, Virginia Tech, affiliated with the Department of Science, Technology and Society, the Department of Philosophy, the Center for Human-Computer Interaction, and the Center for Future Work Places and Practices. His research focuses on how cultures and cultural norms shape the cultivation of responsible engineers and the development and deployment of robotics and AI-enabled technologies. He serves as an Associate Editor for *Science and Engineering Ethics* and *Studies in Engineering Education*, and a member of the Board of Directors of the Association for Practical and Professional Ethics.