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Ethics of Artificial Intelligence and Automation in Digital Agriculture

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As with industrial sectors of the economy, agricultural production is constantly transformed through technological innovation. Technological advances from the Jethro Tull seed drill and the steel plow to modern tractors have radically altered how agriculture is practiced. Artificial intelligence (AI) and digital agriculture (DA) are poised to revolutionize agriculture again.

While experts point to economic returns in the form of increased efficiency and decreased labor costs as primary drivers of automation and AI in agricultural production, widespread deployment of DA will also have ethical and social costs and implications. Though some of these are still unknown, others can already be discerned; researchers and policy makers should consider these as they make decisions about how to integrate technology, design work processes, and strategize about future investments.

Some of the issues we raise include whether automation will decrease overall innovation in the agricultural sector via human de-skilling, how important "manual," embodied labor experiences are to cultivating the knowledge to develop and transform agricultural systems, and whether hybrid systems that combine human workforce with AI will be more effective than systems that aim at whole-scale replacement.

We consider some of the transformative effects of DA on agricultural systems and workers, outline some ethical concerns surrounding this transformation, and offer strategies to mitigate them. Our normative analysis adopts what technologists call a "human-centered design" approach. Rather than thinking of automation as the removal of human users, human-centered design asks how to best incorporate human expertise, skills, and interaction into a technical system. This approach recognizes that human-technological couplings are mutually informing, which can lead to "up-skilling," the production of novel, salient skills, or de-skilling, the elimination or reduction of distinctive and previously prized skills in a particular industry due to automation.

The human-centered approach allows us to consider ways in which technology can better integrate with, support, and extend human skills and social needs in order to assure greater long-term gains. In particular, the human-centric perspective looks for ways to design technological systems in ways that promote up-skilling and re-skilling rather than de-skilling (Rafner et al., 2022).

Ethical Issues Related to DA in Agriculture

DA has the potential to automate certain tasks and processes currently executed using human labor. The extent to and pace with which DA will replace or reallocate human workers is still unknown and will likely proceed unevenly, depending upon the extent of variability in the operational context (Zorpette, 2023). Discourses on AI and automation have generally tended to overstate the capabilities of existing systems to operate autonomously. This is at least in part because so much of the business case for DA revolves around the prospect of labor cost savings (Bender et al., 2021). We argue in this section that ethical issues related to DA exist in the sometimes-obscured zone of interaction between AI and human workers. The issues we will focus on in this section relate particularly to labor replacement and de-skilling.

Many of the issues around replacement and de-skilling are not limited to DA and generalize across operational contexts and sectors. However, features specific to the agricultural sector are salient to our analysis of ethical issues in DA in ways worth making clear at the outset. Agriculture is particularly reliant on a precarious, aging workforce, with specific vulnerabilities exceeding those of workers in other sectors of the U.S. economy. While existing labor shortages in agriculture are expected to intensify, driving DA research and adoption, the highly variable and unpredictable nature of agricultural work, intensified by climate change, makes technological integration a challenging task (Christiaensen, Rutledge, and Taylor, 2020). Successful DA adoption is notably reliant on the depth of experience of an aging workforce

that it also risks displacing (Hsu and Bustillo, 2023a). This means that implementation will require intensive collaboration with workers that may be ambivalent about DA efforts and goals. Yet, there has been little thought devoted toward the creation and fostering of better collaborative contexts. Thus, below, we focus on the categories of "consent" and "hybrid exchange" to specify a framework to improve prospects for collaboration between researchers, technology, and workers.

Labor Market Displacements: Negotiating Impacts

Digitalization and AI are increasingly promoted as solutions to ongoing labor and workforce shortfalls in North American agriculture (Kugler, 2022) as a way to hasten the exit of human workers engaged in purportedly low- or unskilled "routine manual work" (Christiaensen, Rutledge, and Taylor, 2020; Schlogl and Summer, 2020). Some of these labor shortfalls are due to an aging workforce, increased challenges with traditional labor pipelines due to stricter controls on immigration and legal migrant workers, and an inability to attract and retain a younger and/or domestic workforce in the United States. Experts estimate that "more than half of all farmworkers in the US are foreign-born and undocumented" (Hsu and Bustillo, 2023b)."

Industry-specific examples shed more light on the demanding conditions that agricultural workers face. In Louisiana's sugarcane processing industry, the season can stretch to up to 120 days (weather-dependent), and all of the personnel employed by the factories (including owners and managers) report for 12-hour shifts, 7 days per week, without holidays (Mandalika, 2023). A stretched workforce means that additional shifts are near impossible to incorporate. In a tight labor market, with higher-paying jobs available in competing sectors, agriculture increasingly relies on foreign-born, migrant workforce population sourced through guest-worker programs. Moreover, the industry is aging, and the workforce is not being replenished with younger workers at a fast-enough pace. In a recent survey conducted among sugarcane factory personnel in Louisiana, the vast majority (~78%) of stakeholders reported that their careers extended 20–30 years and greater (Mandalika, 2023).

In this context, DA is driven by the perceived need to replace humans and human knowledge with data-driven, automated systems. The primary ethical challenges of this proposed transition have to do with the potential negative consequences of labor replacement and de-skilling at the individual, organizational, and social level. While loss of jobs to automation has, historically, been compensated by the creation of new jobs across the broader economy, individual and local effects of widespread job loss due to automation can take decades to overcome. Though technological investments may create new roles in the agricultural sector that will feature novel AI-human interactions, the overall number of workers employed in agriculture is likely to decrease with automation (Holzer, 2022). Thus, it is crucial to better understand and anticipate the impact of DA on workers and their communities as well as on the sector as a whole.

Vulnerable Workforce

Agricultural workers are vulnerable beyond those vulnerabilities that affect workers generally. This vulnerability has several dimensions. There is a legal dimension: U.S. farmworkers have fewer legal protections, generally, than workers in other sectors. "Federally, farmworkers are largely excluded from many federal workplace safety regulations. They don't have a right to overtime pay or to unionize, and children as young as 12 can legally work in the fields" (Hsu and Bustillo, 2023a).

The second dimension of vulnerability is the difficulty farmworkers have in accessing protections. Even where workers do have formal protections, there may be few avenues to pursue legal redress that do not expose workers to retaliation, loss of employment sponsorship, or deportation. Workers on visas are tied to their employers for housing, transportation, and documentation (Hsu and Bustillo, 2023a).

Perhaps ironically, factoring in agricultural workers' vulnerability may be part of building the "ethical" case for DA. Rather than improving occupational and legal safeguards and addressing ongoing concerns, DA promises to lessen reliance on forms of labor that some view as ethically compromised because of endemically abusive labor conditions. The thought goes something like this: If producers cannot or will not lessen their reliance on vulnerable labor groups—by offering higher wages or cultivating new workforce pipelines—DA promises to dissolve the ethical concern entirely, maintaining or improving efficiency without increasing unit costs.

Of course, this case for DA leaves another source of ethical concern unaddressed. Sector-wide introduction of DA will expose substantial populations of vulnerable workers to loss of livelihood in the absence of access to adequate social safety nets. While some workers will be able to transition to new roles, automation guarantees to displace more workers than it retains. Thus, DA as currently envisioned is likely to reproduce some of the same social dislocations seen with automation in manufacturing. Its advocates should consider ways to support strengthening access to social safety nets, noting that, in the United States, these vary widely between states. Unfortunately, the costs of these dislocations are easy for policy makers and proponents to hide from view. Undocumented or short-term visa holders are "nobody's constituents"—politically speaking—and do not elicit moral concern among many US voters (Amin, 2021; Vila-Henninger, 2019). On our view, improving social safety nets, including

opportunities for re-skilling and up-skilling—and access to these by all affected workers including foreign-born and undocumented—is the only solution to the social and individual costs of labor replacement due to automation.

Analyzing and weighing the ethical costs and benefits of DA from the point of view of labor displacement, however, obscures another critical and ethically salient dimension of DA—at least in the near-term. DA, at present, may be more a promising and rapidly developing research program than a reality on the ground. However, this does not prevent employers from using DA as a tool—or cudgel—to discipline workers and to hide labor abuses. We are referring here to the way the threat of automation can and has been used historically to discourage demands to improve salary and working conditions (Montgomery, 1987). Just as agricultural employers have used foreign work visas as tools to discipline workers who seek to organize for better working conditions, so do employers use the threat of job automation (Golin and Rauh, 2023). This weakens the possibility of positive collaborative attitudes necessary for knowledge transfer (more of which below).

Finally, rather than automation mitigating issues related to labor abuse, we have seen evidence of the rhetoric of DA deployed to weaken attempts to regulate and enforce global labor standards. For example, researchers of forced labor have documented how suppliers of cotton have used claims about the full automation of agricultural processes to skirt compliance with international labor regulations. Because automation implies that work is being done without intensive human labor inputs, products like Xinjiang cotton, banned for incorporating involuntary Uighur labor, attempt to by-pass regulations by overstating the extent of their mechanization (Murphy, 2021).

Ethics Issues Related to De-Skilling

"De-skilling" describes one of the negative effects of the replacement of human labor by automation. Historically, with automation, workers lost important elements of their autonomy in initiating tasks and setting the tempo for work (Noble, 1977). More specialized, artisanal tasks were taken over by mechanized processes now controlled by managers. This loss of autonomy intensified, first with the introduction of machines and factory assembly lines, time- and motion-based management, and then with large-scale automation of the factory and warehouse floors (Laurie, 1987).

The sorts of harms associated with de-skilling—degradation of the conditions of labor—and their effects on individual autonomy are issues of moral concern. However, these costs are arguably balanced by gains in productivity. These sorts of trade-offs—between labor conditions, individual autonomy, and the conditions of economic production—are central normative issues in contemporary ethical debates about automation and the future of work (Danaher and Nyholm, 2021). However, the sort of de-skilling and autonomy loss relevant to AI/DA automation is arguably of a different sort than previous rounds of mechanization and automation. It therefore deserves to be understood on its own terms in order to better weigh risks, costs and benefits.

In the case of DA, the agricultural workforce is threatened by two distinct sorts of de-skilling. The first results from moving from work processes with humans in the loop (HITL), humans coupled with machines, to humans on the loop (HOTL), supervising largely automated processes (Rafner et al., 2022). Take the case of airplane pilots that oversee the automated flight equipment of the planes they fly. While pilots in the United States enter the profession with high-level skills, necessary reliance on automated flight systems make it difficult to keep these skills fresh and ready to use in the event that they are needed. As Elish (2019) notes, humans moved to "supervisory" roles with respect to an automated task are often situated in a "moral crumple-zone." The latter term "describes how responsibility for an action may be misattributed to a human actor who has limited control over the behavior of an automated or autonomous system" (Elish, 2019, p. 41). Tasked with intervening in the case of a crisis, humans are nonetheless often poorly positioned to do so effectively because of the way these systems are designed.

Researchers, including Elish, argue that putting humans on the loop as crisis managers is often the worst way to design the interactive potential of humans and technology in work processes (Rafner et al., 2022). They argue that much more thought should go into how to meaningfully incorporate humans to mitigate risks and how to create hybrid, AI-human collaboration that would maximize the potentials and skills of each "partner." Examples of such a hybrid system, include "self-driving" cars that know when and how to yield control to the human driver in a timely manner to avoid a crash (Elish, 2009) and music-editing and -mixing tools that iteratively interact with skillful listeners (Bryan and Mysore, 2013). In both cases, performance of the hybrid system can exceed the fully automated system. However, present models for human worker-AI coupling often do not adopt a human-centered design perspective. Often, this is because the business case for automation assumes either human labor replacement or de-skilling. By contrast, a human-centered design perspective seeks to design work processes that minimize de-skilling and "moral crumple zones" and make genuine interaction and learning possible between human and AI technology. This perspective is crucial to avoiding the introduction of excessive risks related to automation but potentially is also critical to achieving DA with maximal benefits, especially in contexts where knowledge transfer is crucial.

In this section, we have covered some general issues

related to de-skilling. However, taking a more global view, additional issues and questions emerge related to knowledge- and risk-management at the social level. It is widely acknowledged that, with a few exceptions like airplane pilots, moving from HITL to HOTL involves a reduction in human labor inputs. Indeed, this reduction of reliance upon expensive human labor inputs is usually how the economic case is made for adopting these technologies—including the case for increased DA. Widespread adoption of DA, then, could involve a potentially large-scale loss of human workforce capacity in agriculture, of the sort that would parallel the loss of U.S. industrial workforce capacity in the last decades of the 20th century.

Other ethical issues here include macro-level questions: specifically, whether and to what extent HOTL and humans out of the loop (HOOTL) systems may create less resilient, less adaptive systems than the ones they replace or the extent to which they might threaten the security of food systems. In an era of climate change, where the past is not necessarily a guide for the future, the question of how to safeguard vital food systems in the context of a shift toward DA is paramount (Lajoie-O'Malley, et al., 2020). Policy makers have to ask whether massive de-skilling of an agricultural workforce is compatible with long-term food-security. As contemporary challenges to revive certain domestic manufacturing sectors (e.g., computer chips) demonstrate, cognitive ecosystems and workforce pipelines, once dismantled, are difficult to reconstitute.

De-skilling is a major issue in every industry facing automation and AI. In this context, we advocate for a human-centered design approach to technological implementation, particularly for those processes characterized as HOTL or HOOTL. This human-centered approach involves a set of commitments to design human-technology interaction that privileges the needs and cognitive niche of humans and promotes human autonomy both individually and socially.

Ethical Issues around Knowledge Capture and Transfer in DA

We deal with the ethical issues related to the condition for the sort of displacement and de-skilling described above, namely knowledge transfer from humans to intelligent, data-driven systems. Due to traditionally high and increasing variability in agricultural production, DA integration faces a steep learning curve that necessarily passes through experienced workers (Ingram and Damian, 2020). To develop and integrate DA tools and systems, we rely on worker experience and knowledge. However, the necessary "collaboration" between existing workforce and DA may be hampered by a number of factors, including the perceived threat that automation poses to workers, lack of adequate incentives for interacting with DA, and technological interface and systems design that fail to facilitate interaction and "learning" between human and AI.

Critics have argued that existing generative AI (e.g., DALL-E) appropriate human intellectual property (as training data) without adequate compensation, clearance, or accreditation. For example, generative AI like DALL-E or Stable Diffusion can make images in the style of certain artists without those artists having been compensated (Appel, Neelbauer, and Schweibel, 2023; Dehouche and Dehouche, 2023). Other AI ethicists have pointed out that AI systems problematically hide persistent reliance on human labor, in part to create the illusion of an autonomous, HOOTL system. For example, labor-intensive work, necessary to label and clean training data of pernicious and socially damaging content is farmed out via Amazon Mechanical Turk (Bender et al., 2021).

This critical literature points toward a general conclusion with respect to the ethical issues related to knowledge transfer in AI. Presentations of AI as autonomous, agential systems can mask the extent to which humans are very much "in-the-loop" in producing and calibrating AI systems. There is ongoing knowledge-transfer, which, when concealed, tends to mask areas of human-AI interaction that are ethically salient. AI developers may be incentivized to obscure this ongoing knowledge transfer in order to avoid thorny questions about compensating the workers with the knowledge to "train" the DA.

Knowledge capture and transfer from human workers to instrumentation and machinery, is often guided by other human researchers and engineers. In this context, the normative notion of consent is critical. Consent refers generally to the necessary conditions to freely contract. Among these conditions are absence of coercion, sufficient knowledge of the likely consequences of actions (context), and sufficient power to reject the agreement. Making offers someone cannot refuse or deceiving them about the nature of the interaction are examples of coerced and therefore illegitimate contracts (Sandel, 2009).

While owners and managers of agribusinesses grasp the consequences of knowledge transfer, it is not clear that the workers themselves do. Several factors such as the language barrier, literacy, immigration status, and power differentials between the workers, employers and researchers make consent difficult to obtain. The conditions for consent have to be developed and achieved rather than assumed to exist at the outset.

The issue of consent in knowledge transfer, while critical for all interactions, is perhaps most pertinent, at the moment, for DA researchers working in the field (Klerkx, Jakku, and Labarthe, 2019). Just as research requires proper attribution in published work, and consent for all who participate in a study, so must research in DA conform to the principles of the ethical conduct of

research. This means that the question of consent is central to DA and researchers must take positive steps to achieve affirmative consent. If successful integration of AI and automation is linked to the knowledge and skills of experienced workers, then knowledge transfer requires consent. Would workers be (as) willing to share their knowledge and skills, if made aware of the likely outcomes of the DA integrations being pursued?

This issue of consent, as we have already suggested, is particularly thorny in case of vulnerable individuals and populations. Formalized frameworks can help ameliorate this difficulty, particularly in the context of public-private research partnerships related to DA. For example, in a study surveying Irish DA researchers, participants reported need for formalized mechanisms corresponding with "Responsible Research and Innovation" (RRI) capable of responding to negative and consequences of DA proliferation (Regan, 2021). This study also found that DA research projects were more likely to incorporate RRI when directed to do so by research funding agencies. Such requirements are valuable because the institutional settings in which researchers operate may lack incentives for RRI practices, including those related to stakeholder engagement (Ludwig, Macnaghten, and Pols, 2019). Even where these exist, stakeholders are most often construed to be farmers rather than workers. This focus on farmers and owners, however, obscures the problem of consent in knowledge transfer outlined above. Institutional frameworks that support RRI in DA efforts, then, can bring workers' role in DA knowledge transfer into focus. A practical approach to incorporating consent into DA research and outreach can include a preliminary discussion with all impacted participants (e.g., farmers, owners, and workers), explaining the research objectives, deliverables, and potential impacts to each stakeholder group. While we do not presume that certain stakeholder groups, such as workers, do not comprehend the long-term impacts of DA research and associated methodologies, we suggest that it behooves researchers working in this field to be explicit of perceived outcomes (positive and negative as pertains to each stakeholder subgroup).

The notion of compensation for knowledge capture and transfer is a general unresolved issue for AI research and development. Yet, in some way, the sector's reliance on situated workers with deep contextual knowledge suggests opportunities to develop models for human-AI collaboration and interaction that might include novel incentives and compensation schemes. Given the high variability inherent in agriculture, it is possible that DA guided by visions of automating away workers will give way to a vision of DA guided by a more collaborative, hybrid model of AI-human interaction. In such a system, "learning" is not unilateral, with knowledge going from human to AI, but bilateral, enabling systems that are mutually informing. If this turns out to be the future of agricultural work, then incentives for worker collaboration might include additional compensation, along with opportunities for re-skilling and up-skilling.

Conclusions

The spread of DA is poised to again revolutionize agriculture, bringing benefits to traditional stakeholders, viz., farmers, agribusiness employers, and industrialists. Minoritized stakeholders such as farmworkers, particularly those who are migrants, have heretofore been rendered voiceless in this process, in part due to a lack of engagement from DA practitioners. In this paper, we have identified labor market disruption, increased workforce vulnerability, de-skilling and coerced knowledge transfer as particular concerns surrounding DA integration. DA researchers and practitioners need to be mindful about ethical issues surrounding knowledge capture and transfer from vulnerable workforce populations to automated systems. This is not only because this is the right thing to do, ethically speaking, but also because creating the conditions for genuinely collaborative processes may mean the difference between success and failure of technological integration. We believe that addressing these issues thoughtfully and adequately will require novel collaborative efforts across academic disciplines, commercial technology developers, and producers. Finally, since agriculture has been slower to adopt technology and AI than other sectors of the economy, stakeholder are well-positioned to integrate some of the concerns we have raised here to investigate new possibilities for DA integration.

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