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Technology Strategy and Management

Artificial Intelligence and the Future of Professional Work

Considering the implications of the influence of artificial intelligence given previous industrial revolutions.

IF YOU ARE a software engineer or a data scientist, your job did not exist a century ago. A century from now, your job will most likely look quite different. One driving force behind such work transformation is artificial intelligence (AI). Dwelling on the nearer term, the next decade or two, projections on the proportion of today's jobs that are susceptible to automation vary enormously—from 9% (in OEDC countries)[2] and 47% (of 702 occupations)[7] to 96% (740 out of 769 occupations).[6,8,9] Why is there such wide variation? What makes it difficult to predict with greater precision? And should we alter the way we think about jobs, given that better education is no longer a protection against risk of technological unemployment? This column addresses these questions, so that we might make better decisions about the future of work for our children and grandchildren.

History of Automation and Its Impact on Jobs Before AI

We are in the midst of the so-called fourth Industrial Revolution that fuses advances in AI, robotics, the Internet of Things, 3D printing, genetic engineering, quantum computing, and other technologies to bring about enormous improvements in efficiency and productivity. A brief historical review of how technologies in the earlier industrial revolutions affected work helps trace implications for the current industrial revolution.

The first Industrial Revolution was associated with the advent of the steam engine in the 18th century, enabling the mechanization of production. Productivity increased in textile and other factories as they switched their energy source from watermill to steam. The second Industrial Revolution in the 19th century was triggered by electricity and the application of scientific principles, which led to the proliferation of mass production. Images of the early 19th-century Luddites who destroyed textile machinery as a way of protesting against mechanization and of Charlie Chaplin hardly keeping pace on the assembly line in the film *Modern Times* remind us that a fundamental change in work was taking place. Industrial engineers designed production processes, and factory workers executed the preplanned tasks typically on an assembly line. In effect, craftsmen's work was disaggregated into standardized tasks that could be carried out by semi-skilled operatives.

The third Industrial Revolution began with the emergence of computing machinery in the 1950s. This led to further automation of manufacturing using Computer-Aided Design (CAD), Computer-Aided Manufacturing (CAM), and the application of digital technology to communications (with the Internet), banking (with ATMs), and other service industries including logistics. While the first two industrial revolutions led to the substitution of mechanical power for human brawn (that is, muscle and handiwork), the third Industrial Revolution computerized human brainwork of the repetitive and routine sort (that is, financial calculation using spreadsheets). And computerization automated a broad range of white-collar workers including clerical, technical, and professional workers.

What's Different with AI?

AI automates tasks normally requiring human intelligence, a definition that distinguishes itself from automation of manual tasks. How does AI change what human workers do? Before the spread of machine learning (ML), enabled by massive processing power and data storage capabilities, the following propositions became compelling.

First, a job consists of interrelated tasks, and it is tasks, not jobs, that are automated by computers.[3] 'Routine' tasks, which are easy to codify, tend to be automated; 'non-routine' tasks that require more tacit problem-solving capabilities, intuition, creativity, and persuasion are difficult to automate. For example, financial analysts build models to automate the prediction of stock prices, but they cannot automate the task of interpreting the prediction results and advising their clients. A key reason for the wide variation in the share of jobs 'at risk of computerization,' mentioned earlier, is due to different ways in which task-level analysis is aggregated into jobs. Second, some tasks are substituted for by computers, but others complement computers.[4–5] For example, while automating calculation substitutes for human calculation, the rise in demand for automated calculation leads to a demand for complementary tasks in computer programming by humans.

With the advent of machine learning (ML), these propositions must be modified. First, *the distinction between 'routine' and 'non-routine' tasks may cease to make sense in considering what human tasks are substituted for, and complemented by, AI*. We might think of AI as pushing the frontier of what are non-routine tasks, as machines become more capable of codifying what used to be tacit. However, an alternative, quite different, way of thinking about this is to consider machines performing tasks in such a way the 'routine' vs. 'non-routine' distinction no longer applies. This is because machines can follow rules that do not need to reflect the rules that human beings follow at all. For example, rules followed by a machine—be it a self-driving car or a facial-recognition algorithm—are not the same as the rules followed by humans engaged in the same activity. We therefore wish to avoid the 'AI fallacy'[12] of believing the only way to develop AI systems is to replicate the thinking process of human experts. This has become obvious with ML, letting machines infer rules from abundant data, in contrast to 'expert systems' for which a human domain specialist must articulate a set of rules for a machine to follow.

Second, *new tasks will be created by AI, but how these tasks will be bundled into jobs, new or existing, remains uncertain*. One study classifies new jobs (though they are really tasks) that AI will create into three types—trainers, sustainers, and explainers.[13] *Trainers* teach AI systems—chatbots or digital assistants such as Siri and Alexa—how they should perform, especially in showing empathy or in detecting sarcasm. *Explainers* as algorithm forensic analysts know the inner workings of complex algorithms, and can explain to nontechnical human resource professionals, for example, how a recruitment system identified the best candidate for a job. *Sustainers* help ensure AI systems are operating as designed, and that unintended consequences are addressed with appropriate urgency. Training, explaining, and sustaining appear to require different knowledge bases. Will they, then, be carried out by separate expert groups? Or will these roles be incorporated into existing occupations (for example, compliance professionals incorporating the sustaining task)? We do not yet know the answer to these questions.

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Impact of AI on Professional Jobs

What is the implication of the preceding discussion on professional work of the future? Professional jobs are part of the 'professional, technical, and managerial occupations' in government statistics, and include scientists and engineers, as well as accountants, lawyers, and doctors. We focus on professionals, defined as possessing an expertise, a body of knowledge, and a service ethic,[11] because they are said to be most threatened by AI. This focus may provide a clue to the possible emergence of new professions.

First, just as craftwork was disaggregated into tasks in the second Industrial Revolution, professional work has been subjected to task disaggregation in the third and fourth Industrial Revolutions. Legal practice of giving advice to clients, for example, may be disaggregated into the tasks of defining the client's problem, reviewing documents around the problem, and explaining the result of that analysis to the client. With the application of AI and ML in particular, machines substitute for the task of reviewing documents. Machines also require complementary task inputs from data scientists and project management professionals working in multidisciplinary teams.[1] Thus, it helps to identify which professional tasks can be substituted by AI, and which tasks are complemented by AI.

Second, technological frontier is not the only factor determining what machines do and what humans end up doing. Humans may remain in the loop to ensure maintaining social and ethical norms. In particular, professional norms, sometimes buttressed by government regulation, enable a

professional group to claim an exclusive domain of expertise. For example, only doctors with a license can practice medicine, and only lawyers with a license can practice law. AI adoption in their specific field may lead to delegating what they used to do to machines, but the oversight function is likely to remain with those licensed professionals.

Third, the way tasks might be rebundled into professional jobs depends on professional control. In many workplaces, from hospitals to business corporations, multidisciplinary teams of different professionals are becoming important. This multidisciplinary teamwork is likely to lead to more 'hybrid professionals' who develop a relational capability vis-à-vis expertise in other areas.[10] At hospitals, doctors may extend their domain to take control of the delivery of good quality patient care, not just to treat patients. Moreover, a new medical practitioner might emerge to ensure the delivery of AI-assisted patient care. Similarly, computing professionals themselves may incorporate all of the training, explaining, and sustaining roles in AI adoption. But an equally plausible scenario is the rise of new AI professionals that focus on the new tasks of training, explaining, and sustaining. The revised ACM Code of Ethics and Professional Conduct obliges computing professionals to "monitor the level of integration of their systems into the infrastructure of society."[a] However, the more ubiquitous the AI technology becomes, the more challenging it would be to incorporate these new tasks into the existing computing profession.

Thus, the professional control perspective gives some hint at, but leaves open a variety of resolutions to, how AI may give rise to new occupations. Because social and ethical concerns are paramount, how tasks are bundled into professional work is likely to differ from occupation to occupation.

Conclusion

The impact of AI on the future of work should be framed in terms of tasks, not jobs, automated by AI. AI substitutes some tasks, complements others, and creates new tasks. How this complex interplay of substitution, complementarity, and creation rebundles tasks into existing or new jobs remains uncertain. For this, we must take account of social and professional norms over and above technological feasibility. The professions perspective is useful for considering the future of work, as professionals are increasingly expected to become 'hybrid' in capability relating to and sometimes incorporating expertise in other areas.

The impact of AI on the future of work should be framed in terms of tasks, not jobs, automated by AI.

a See http://bit.ly/2GYtNFq

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Calendar of Events

Mar. 30–Apr. 3
SAC '20: The 35th ACM/SIGAPP Symposium on Applied Computing, Brno, Czech Republic, Sponsored: ACM/SIG, Contact: Chih-Cheng Hung, Email: chung1@kennesaw.edu

Apr. 20–24
ICPE '20: ACM/SPEC International Conference on Performance Engineering, Edmonton, Canada, Co-sponsored: ACM/SIG Contact: Jose Nelson Amaral, Email: amaral@cs.ualberta.ca

Apr. 21–24
CPS-IoT Week '20: Cyber-Physical Systems and Internet of Things Week 2020, Sydney, Australia, Sponsored: ACM/SIG, Contact: Wen Hu, Email: wen.hu@unsw.edu.au

Apr. 21–25
ICCPS '20: ACM/IEEE 11th International Conference on Cyber-Physical Systems, Sydney, Australia, Sponsored: ACM/SIG, Contact: Linda Bushnell, Email: lb2@uw.edu

Apr. 21–25
IPSN '20: The 19th International Conference on Information Processing in Sensor Networks, Sydney, Australia, Sponsored: ACM/SIG, Contact: Kusy Branislav, Email: brano.kusy@csiro.au

Apr. 22–24
HSCC '20: 23rd ACM International Conference on Hybrid Systems: Computation and Control, Sydney, Australia, Co-sponsored: ACM/SIG, Contact: Aaron Ames, Email: ames@caltech.edu

Apr. 25–30
CHI '20: CHI Conference on Human Factors in Computing Systems, Honolulu, HI, Co-sponsored: ACM/SIG, Contact: Philippe Palanque, Email: palanque@irit.fr