Algorithms at Work: Empirical Diversity, Analytic Vocabularies, Design Implications

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Abstract
Computational algorithms have recently emerged as the subject of fervent public and academic debates. What animates many of these debates is a perceived lack of clarity as to what algorithms actually are, what precisely they do, and which human-technology-relations their application may bring about. Therefore, this CSCW workshop critically discusses computational algorithms and the diverse ways in which humans relate to them—focusing particularly upon work practices and investigating how algorithms facilitate, regulate, and require human labor, as well as how humans make sense of and react to them. The purpose of this workshop is threefold: first, to chart the diversity of algorithmic technologies as well as their application, appropriation, use and presence in work practices; second, to probe analytic vocabularies that account for empirical diversity; third, to discuss implications for design that come out of our understandings of algorithms and the technologies through which they are enacted.

Author Keywords
Computational algorithms; work practices; algorithmic management; work technologies.

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

Introduction

Computational algorithms have come to play a key role in many human activities: search algorithms structure our search for information online; algorithms in business management systems suggest how employees are best allocated to different tasks and shifts; algorithms used in peer-to-peer platforms enable new types of ad-hoc trade in labor, skills, knowledge and material goods; and algorithms in monitoring systems, such as traffic management, help forecast events and identify future situations that may require intervention.

In the last three years, we have seen fervent public debates [15] and growing scholarly interest [9, 10, 12] in computational algorithms and the ways in which humans rely upon them. 'Algorithms' have emerged as a new topic of CSCW research. Yet algorithms have been the bread and butter of computer technology for decades. So, what is *new* about computational algorithms? And what has changed to inspire this new interest?

To answer these questions, it is important to chart the phenomenon in its diversity, in particular the human response to algorithms; develop adequate, nuanced yet comprehensive, analytic vocabularies; and contribute design implications for both algorithms and the technologies in which they are embodied. This workshop seeks to do this with a focus on computational algorithms in work practices. In the following sections, we review existing research on algorithms and outline the focus, goals and activities of the workshop.

Problems in computational algorithms

Drawing on large amounts of detailed data, computational algorithms are increasingly employed as instruments of prediction, evaluation, and coordination of human behavior. At the same time, algorithmic complexity may generate output that users find difficult to understand and rely upon. Scholars have begun to problematize three major concerns that the increasing proliferation of computational algorithms raises:

First, computational algorithms often 'hide' their functioning from their users and bystanders. They are, some argue, to a large degree *technically and intellectually inaccessible* to most of us: "[…] algorithms remain outside our grasp, and they are designed to be" [4, p. 192; 15; 5]. Given their computational complexity, design, and implementation, computational algorithms can generate impenetrable outcomes, that is, ones which can be difficult for different actors to make sense of. According to a particularly stark claim, not even the developers of some computational algorithms (i.e., the 'authors' of their code) understand precisely what computational algorithms do [1]. Sense-making, however, is a pre-condition for trust and, subsequently, for competent and sustained technology use [16].

Second, effective computational algorithms are typically *more than data-processing code*. They crucially rely upon human work. Computational algorithms often prescribe protocols for human work [7] and thereby make human work the prolonged arm of computation [3]. Insofar as algorithms are more than code, simply

rendering 'hidden' code technically and intellectually accessible will not do. Instead, algorithms may have to be understood as an iterative socio-technical performance [6].

Third, algorithms are transforming work practices and consumer experiences, but they may not always do so in a fair way [8]. Algorithms are frequently represented as objective, fair, and trustworthy by platform owners and users [4, p. 179; 10; 13]. However, this portrayal of algorithms hides the human labor on which they rely and discourages questioning of the "fair" decisions made by these algorithms. However, algorithms can—intentionally or unintentionally—make discriminatory decisions that may affect users and workers [14, 15]. It is unclear how such discriminatory judgment can be identified because the inner workings of algorithms are often unknown and accountabilities of developers, workers, or the algorithm itself are difficult to determine [1, 11].

Research on algorithms in the Workplace

Recent research in CSCW has begun to examine how algorithms change work practices in a variety of different workplaces and emerging domains. In particular, research has explored how algorithmic management influences workers in the "peer economy" and through "microwork".

The emergence of the peer economy, which uses peer-to-peer platforms to enable new types of ad-hoc trade in labor, skills, knowledge and material goods [2, 8] is just one recent and prominent example of how "algorithmic management" [9] plays an increasing role in the production and consumption of services. Peer-to-peer platforms use algorithms to manage large numbers of typically small interactions between individuals. How the algorithms are constructed (e.g., what they take account of and what they do not) plays a direct role in the experience of the service for both the individual service provider and receiver. Yet it is the platform owners who determine what the algorithms take account of and typically their workings are not revealed to the users.

Research has also explored the ways in which human labor supports algorithmic decision-making. The function of many computational algorithms relies upon human microwork, crowdsourced micro-tasking [7], a division of labor that has been described as "heteromation," i.e., as enlisting humans for critical tasks [3, 10]. As concepts, microwork and heteromation focus on technology users who have little power over the technological systems they deal with.

To fully account for the presence of computational algorithms in the workplace, future research will need to study not only the microworker but the "macroworker," the powerful decision-makers who implement algorithms to their advantage as well.

Focus: Algorithms at work

This workshop focuses on computational algorithms and their role in the workplace, a domain where human labor and computation are increasingly intertwined. The workshop discusses how data-intensive work practices rely on computational algorithms and how computational algorithms rely on human work—these work practices constitute a new division of labor between collaborating humans and technology. This division of labor is likely to emerge as key characteristic of the future of human work.

To account for such division of labor, we need to characterize:

- where computational algorithms are used in workplaces (i.e., in what sorts of workplaces and activities),
- what computational algorithms contribute to work practices (e.g., how they filter, rank, and coordinate human activity),
- how deeply and how critically this contribution is understood by human collaborators,
- what human workers contribute to make computational algorithms work,
- how algorithms influence labor practices at different infrastructural layers (i.e.., from software to hardware),
- what physical infrastructures are necessary to support algorithms,
- what human labor is involved in developing and maintaining these infrastructures,
- what impact working with algorithms has on workers as individuals and collectively,
- how this impact may serve as a feedback for altering work practices or for designing better algorithms,
- how these evolving work practices and algorithms impact labor markets; how they create new kinds of human labor and supplant others.

Workshop Goals: Charting Empirical Diversity, Shaping Analytic Vocabularies and Conceptualizing Design Fundamentals

As a first step, the workshop will discuss the presence of computational algorithms in diverse work practices, ranging from automated journalism to employee management, from to the municipal administration and bureaucratic decision-making to the non-traditional working arrangements of crowdsourcing, peer economies that ride-hailing services, and cryptocurrency mining illustrate. As a second step, the workshop will probe different analytic vocabularies that account—in fruitful and critical ways—for such empirical diversity. Finally, given our understandings of how algorithms impact work practices and peoples sense-making activities, we will attempt to conceptualize common themes and implications for the design of algorithms and the technologies through which they are enacted to improve the experiences of workers and other users.

Investigating Algorithms at Work

In order to understand the contributions that algorithms make to work practices we suggest that researchers explore the similarities and differences across different domains, examining how various actors in these domains make sense of and perceive algorithms. Actors include workers being 'managed' by the algorithms (e.g. Uber drivers), customers or clients where algorithms impact on a service (e.g. Uber customers), as well as the people providing the service/platform (e.g. Uber themselves).

Workers engage in sense-making efforts when confronted with proprietary and complex computational algorithms that manage their work practices. For example, algorithms assign passengers to Uber drivers; however, these algorithms do not take into account driver preferences [9]. How do these sense-making efforts help workers discern when they can trust algorithmic judgment? What kinds of strategic workarounds do they develop and utilize?

In some services algorithms output specific recommendations, such as user ratings or recommendations for courses of action. These typically appear as the summation of a variety of individual inputs, e.g., many individuals may rate a specific driver in Ola (an Indian company similar to Uber); or in an investment platform the algorithm may produce a single 'invest' recommendation as output from multiple trade analysts. How do users make sense of these recommendations? Do they trust them? Can we add value by representing the diversity or range of inputs, rather than taking the sum of the whole? That is, is it useful to enable users to understand how algorithms reflect specific user perceptions and, if so, what are the ways of doing this?

Lastly, how do platform providers make sense of the complex code involved in their algorithms and how workers and users interact with this code? How does this understanding influence their design decisions?

Algorithms at Work—Analytic Vocabularies

Although algorithms have become an emerging research topic in CSCW and related fields, the word "algorithm" has not been well defined. Researchers discuss a wide range of algorithms, from crowdsourcing algorithms to search algorithms to prediction algorithms. However, while this diversity of algorithms in the workplace has contributed to the richness of this area of research, the lack of conceptual clarity creates difficulty in analyzing these algorithms as a whole. In order to account for this empirical diversity through analytic vocabularies we must examine the following:

- what we mean when we talk about (computational) algorithms,
- why we talk about algorithms rather than artefacts, systems, computers, routines, or code,
- where we draw boundaries to determine what are and are not algorithms,
- what attributes algorithms have,
- how we categorize algorithms,
- which algorithms we choose to discuss and study in our research (and which we do not).

Analytical vocabularies can facilitate integration of the work on algorithms into existing conceptual traditions, which will become increasingly important for contextualizing the research on algorithms. Researchers have pointed to the difficulty in developing empirical studies of algorithms [12], whose inner mechanisms are often hidden. Integrating research on algorithms in the workplace into existing conceptual traditions may give researchers a starting point for developing more robust methodologies for studying diverse algorithms.

We propose possible starting points for a conceptual discussion:

- algorithms as *mediation* of human practice, platforms that enable human-to-human interaction,
- algorithms as *performance*, a heterogeneous performance involving both human labor and computation,
- algorithms as *infrastructure*, a certain kind of structure (often invisible, beyond individual grasp, ready-to-hand), shaping and shaped by human activity; this infrastructure is the automated manifestation of managerial power through computation rather than purely through human judgment.

Design implications/guidelines
Given our understandings of how algorithms impact work practices and sense-making activities, we aim to conceptualize implications for design and identify common themes across domains. Two areas promise to be fruitful areas for design:

1. How can algorithms be designed for sustainability (of labor markets, of cities etc.) and fairness? For example, to create a sustainable, fair labor market, the concerns of all actors within that labor market should be taken into account. Such actors can include workers, employers, platform owners, and customers. How should these concerns be weighted, balanced and embodied in the algorithms? How should accountability be built into these systems to ensure that actors have recourse when algorithms are unsustainable or unfair?
2. How can the technologies through which the algorithms take effect be designed to enable sense-making? How can design enable users to understand, and act on the basis of their understanding in a productive way, even where the full complexity of the algorithm remains hidden? How can technologies be designed in ways that are both beneficial for workers and for the whole system?

Call for contributions

We welcome submissions which address the topics above, in particular:

- empirical studies of algorithms in the workplace in all their guises,
- studies or essays which examine or suggest analytic vocabularies for algorithms. Submissions might explore the meaning that "algorithm" has taken on in CSCW research—what are considered to be algorithms and what attributes algorithms are said to have. Submissions could also explore which conceptual traditions and methodologies are compatible with these analytic vocabularies,
- design studies, ideas or implications for design of a) algorithms for work and/or b) the technologies through which the algorithms are enacted and which enable effective use. We are particularly interested in how algorithms and technologies might be better designed to promote, rather than stifle, worker agency.

Workshop papers should be 2-4 pages and submitted by December 15, 2015. At least one author must attend the workshop.

Workshop Activities & Equipment

Prior to the workshop, we ask all participants to read all workshop submissions to ensure focused and deep debate.

In the first half of the workshop, we will have a madness session where all participants can briefly present their submissions for 3 minutes and share their goals in participating in the workshop. We will then focus on a set of presentations given by participants and organizers to set the stage for discussion of future research. In the second half of the workshop, we divide participants into smaller groups. The sub-groups will discuss specific themes reflecting research interests (e.g., the role of algorithms for particular domains, particular conceptual approaches, or design implications), identifying challenges and opportunities in their specific areas. At least one group will engage in design activities.

At the end of the workshop, all participants will share their sub-group activities and identify key action items. The outcomes of the workshop will be used to write a summary report that outlines the current status of research in algorithms at work and future research agenda.

The workshop will be for one day and will not require any specific equipment except a projector.

Workshop Participants & Recruitment

The maximum number of participants is 25 including organizers in order to have a focused discussion around algorithms at work and facilitate potential future collaborations among different stakeholders (industry, government, and academia.) To recruit participants, we will send out a call for participation to different mailing lists, including CSCW, CHI, AoIR, PHD-Design, British HCI, EUSSET, as well as post it on social networking sites such as Facebook and Twitter. We will invite professionals in industry who have experience with in designing or operationalizing algorithmic management in work technologies. We will also create a website describing the goals of the workshop.

Workshop Organizers

Susann Wagenknecht is a researcher at the Department of Social Sciences at the University of Siegen. She studies human-technology relations at the workplace, investigating the role of computational algorithms in expert management practices. Her current work focuses on the use of algorithms in smart city management. She received her PhD from Aarhus University, Centre of Science Studies, in 2014.

Min Kyung Lee is a research scientist at the Center for Machine Learning and Health at Carnegie Mellon University. Her research examines the social and decision-making implications of intelligent systems and supports the development of more human-centered machine learning applications. One of her current projects explores the way algorithmic management changes work practices in on-demand work such as Uber. She received her PhD in HCI from Carnegie Mellon University in 2013.

Caitlin Lustig is an informatics PhD candidate at the University of California, Irvine. Her research broadly explores how power and agency are distributed among actors in socio-technical systems. Her current work uses an empirical study of the Bitcoin's blockchain algorithm to explore ways of designing and supporting distributed and peer-to-peer alternatives to centralized algorithmic systems.

Jacki O'Neill is an ethnographer in the Technology for Emerging Markets research area at Microsoft Research India (MSRI). Her aim is to understand where and how technology can be used to improve the lives of people with lower socio-economic status, whether that be through work, health, education or play. She was previously Principal Scientist at Xerox Research Centre Europe where she focused on the analysis and design of technologies for work.

Himanshu Zade is a research fellow in the Technology for Emerging Markets group at Microsoft Research India (MSRI). His research interests include reasoning how users interact and understand a technology through a bifocal - quantitative and qualitative - analysis of data for identifying meaningful design opportunities. In prior

research, he examined how people learn to use unfamiliar machines, by witnessing, capturing, and measuring their understanding as it evolves with more interaction.

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