INTRODUCTION

The past decade has seen a flourishing of *on–demand work*, largely driven by the reformulation of work as the constituent parts of larger tasks. This framing of work into de–contextualized, modular blocks enables computation to hire workers at scale through open calls on the internet [12, 2, 17]. Distributed paid participants then engage in the work whenever their schedules allow, with little to no awareness of the broader context of the work, and with (often) fleeting identities and associations [23, 21]. In this paper, we use the term on–demand work to join a pair of related phenomena: 1) *crowd work*, on platforms such as Amazon Mechanical Turk (AMT) and other sites of (predominantly) information work; and 2) *gig work*, typically involving platforms for one–off jobs, like driving, courier services, or administrative support. The realization that complex goals can be accomplished by directing and managing crowds of workers spurred industry to flock to sites of labor like AMT to explore the limits of this distributed, on–demand workforce. Researchers have also taken to the space in earnest, developing systems and designs that enable new forms of production (e.g., [1, 3, 27]).

As on–demand work has grown far beyond information work, it has given rise to an increasingly complicated and conflicted culture amongst both the workers who enable it and the researchers who study it. Howe first described crowdsourcing in general terms as "outsourcing [work] to an undefined, generally large group of people in the form of an open call" [12]. However, for years its instantiation was limited to the utilization of human intelligence to process data, participate in scientific studies, and perform information work [16, 36, 39, 8, 28]. More recently, crowdsourcing of physically embodied work — driving and cleaning, for instance — has become a focus for on–demand labor markets [21, 35, 11, 34]. This growth prompted efforts to understand not just the work, but also the workers on these platforms [30, 32]. Some of this research has been motivated by the identification of the sociality of gig work, and the frustration and disenfranchisement that these systems embody [14, 23, 24]. Other work has focused on the outcomes of this frustration, reflecting on the resistance workers express against digitally mediated labor markets [21, 31].

This body of research has broadly sought to answer one central question: What does the future hold for on–demand work and those who do it? Researchers have offered insights on this question along three major threads:

1. **??**? Specifically, (a) How complex are the goals that crowd work can accomplish?, and (b) What kinds of goals and industries may eventually utilize it? [29, 33, 15, 38, 37, 25, 10];
2. **??**? [18, 1, 6, 22, 19, 20, 5, 7, 26]; and
3. **??**? [14, 13, 31, 9, 4, 24]

This research has largely sought to answer these questions by examining the present on–demand work phenomenon. So far, it has not offered a framing for holistically explaining the developments in worker processes that researchers have developed, or the emergent phenomena in social environments; nor has any research, to our knowledge, gone as far as directly predict future developments.

Piecework as a lens to understand crowdsourcing

In this paper, we offer a framing for on–demand work as a contemporary instantiation of *piecework*: a work and payment structure which breaks tasks down into standalone contracts, wherein payment is made for work output, rather than for time. Piecework as a metaphor for crowd work is not new. Indeed, Kittur et al. in 2013 referenced crowd work as piecework briefly as a loose analogy to the form of work emerging at the time [17]. But more than this, the framing of on–demand labor as a re–instantiation of piecework gives us years of historical material to make sense of this new form of work, and allows us to reflect on–demand work through a mature theoretical lens, informed by decades of rigorous, empirically based research.

More concretely, by looking at on–demand work as an instantiation (or even a continuation) of piecework, and by looking for patterns of behavior that the corresponding literature predicts on this basis, we can 1) make sense of the phenomena so far as part of a much larger series of interrelated events; 2) reflect on differences in the factors that impacted piecework historically and impact on–demand work today; and finally, 3) to the extent that history repeats itself, offer predictions of what on–demand work researchers, and workers themselves, might expect to see on the horizon. For example, we will draw on the piecework literature studying task decomposition, which was historically limited in scope by technological limits in measurement and instrumentation, and leverage that understanding to suggest how modern web technology reconfigures this measurement limit for on–demand crowd work.

We organize this paper as follows: we first review the definition and historical arc of piecework to lay groundwork and make clear the analogy to on–demand work (which we will refer to as *crowd work* subsequently, for consistency with prior literature). Then, we interrogate the three major research questions above using the lens of piecework. We will identify similarities and differences between piecework as historically understood and on–demand work as we experience it today. Finally, we will make predictions of future developments based on how those similarities and differences influenced piecework. Finally, we will offer implications for researchers and practitioners based on our results.

References

[1] Michael S. Bernstein et al. "Soylent: A Word Processor with a Crowd Inside". In: UIST '10 (2010), pp. 313–322. DOI: 10.1145/1866029.1866078. URL: http://doi.acm.org/10.1145/1866029.1866078.

[2] Jeffrey P. Bigham, Michael S. Bernstein, and Eytan Adar. "Human-Computer Interaction and Collective Intelligence". In: *Handbook of Collective Intelligence*. MIT Press, 2015, pp. 57–84. ISBN: 9780262029810. URL: http://repository.cmu.edu/cgi/viewcontent.cgi?article=1264{\&}context=hcii.

[3] Jeffrey P. Bigham et al. "VizWiz: nearly real-time answers to visual questions". In: *Proc. UIST '10*. 2010.

[4] Robin Brewer, Meredith Ringel Morris, and Anne Marie Piper. ""Why Would Anybody Do This?": Understanding Older Adults' Motivations and Challenges in Crowd Work". In: *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*. CHI '16. New York, NY, USA: ACM, 2016, pp. 2246–2257. ISBN: 978–1-4503–3362–7. DOI: 10.1145/2858036.2858198. URL: http://doi.acm.org/10.1145/2858036.2858198.

[5] Carrie J. Cai, Shamsi T. Iqbal, and Jaime Teevan. "Chain Reactions: The Impact of Order on Microtask Chains". In: *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*. CHI '16. New York, NY, USA: ACM, 2016, pp. 3143–3154. ISBN: 978–1-4503–3362–7. DOI: 10.1145/2858036.2858237. URL: http://doi.acm.org/10.1145/2858036.2858237.

[6] L. Elisa Celis et al. "Assignment Techniques for Crowdsourcing Sensitive Tasks". In: *Proceedings of the 19th ACM Conference on Computer–Supported Cooperative Work & Social Computing*. CSCW '16. New York, NY, USA: ACM, 2016, pp. 836–847. ISBN: 978–1-4503–3592–8. DOI: 10.1145/2818048.2835202. URL: http://doi.acm.org/10.1145/2818048.2835202.

[7] Joseph Chee Chang, Aniket Kittur, and Nathan Hahn. "Alloy: Clustering with Crowds and Computation". In: *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*. CHI '16. New York, NY, USA: ACM, 2016, pp. 3180–3191. ISBN: 978–1-4503–3362–7. DOI: 10.1145/2858036.2858411. URL: http://doi.acm.org/10.1145/2858036.2858411.

[8] David Geiger et al. "Managing the Crowd: Towards a Taxonomy of Crowdsourcing Processes." In: *AMCIS*. 2011.

[9] Mary L. Gray et al. "The Crowd is a Collaborative Network". In: *Proceedings of the 19th ACM Conference on Computer–Supported Cooperative Work & Social Computing*. CSCW '16. New York, NY, USA: ACM, 2016, pp. 134–147. ISBN: 978–1-4503–3592–8. DOI: 10.1145/2818048.2819942. URL: http://doi.acm.org/10.1145/2818048.2819942.

[10] Nathan Hahn et al. "The Knowledge Accelerator: Big Picture Thinking in Small Pieces". In: *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*. CHI '16. New York, NY, USA: ACM, 2016, pp. 2258–2270. ISBN: 978–1-4503–3362–7. DOI: 10.1145/2858036.2858364. URL: http://doi.acm.org/10.1145/2858036.2858364.

[11] *House Cleaning, Handyman, Lawn Care Services in Austin, Denver, Kansas City, Minneapolis and San Francisco —- Zaarly*. Sept. 2015. URL: https://www.zaarly.com/.

[12] Jeff Howe. *Crowdsourcing: How the power of the crowd is driving the future of business*. Random House, 2008.

[13] Lilly C. Irani and M. Six Silberman. "Stories We Tell About Labor: Turkopticon and the Trouble with "Design"". In: *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*. CHI '16. New York, NY, USA: ACM, 2016, pp. 4573–4586. ISBN: 978–1-4503–3362–7. DOI: 10.1145/2858036.2858592. URL: http://doi.acm.org/10.1145/2858036.2858592.

[14] Lilly C. Irani and M. Six Silberman. "Turkopticon: Interrupting Worker Invisibility in Amazon Mechanical Turk". In: *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. CHI '13. New York, NY, USA: ACM, 2013, pp. 611–620. ISBN: 978–1-4503–1899–0. DOI: 10.1145/2470654.2470742. URL: http://doi.acm.org/10.1145/2470654.2470742.

[15] Joy Kim and Andrés Monroy-Hernández. "Storia: Summarizing Social Media Content Based on Narrative Theory Using Crowdsourcing". In: *Proceedings of the 19th ACM Conference on Computer–Supported Cooperative Work & Social Computing*. CSCW '16. New York, NY, USA: ACM, 2016, pp. 1018–1027. ISBN: 978–1-4503–3592–8. DOI: 10.1145/2818048.2820072. URL: http://doi.acm.org/10.1145/2818048.2820072.

[16] Aniket Kittur, Ed H. Chi, and Bongwon Suh. "Crowdsourcing User Studies with Mechanical Turk". In: *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. CHI '08. New York, NY, USA: ACM, 2008, pp. 453–456. ISBN: 978–1-60558–011–1. DOI: 10.1145/1357054.1357127. URL: http://doi.acm.org/10.1145/1357054.1357127.

[17] Aniket Kittur et al. "The Future of Crowd Work". In: *Proceedings of the 2013 Conference on Computer Supported Cooperative Work*. CSCW '13. New York, NY, USA: ACM, 2013, pp. 1301–1318. ISBN: 978–1-4503–1331–5. DOI: 10.1145/2441776.2441923. URL: http://doi.acm.org/10.1145/2441776.2441923.

[18] Ranjay A. Krishna et al. "Embracing Error to Enable Rapid Crowdsourcing". In: *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*. CHI '16. New York, NY, USA: ACM, 2016, pp. 3167–3179. ISBN: 978–1-4503–3362–7. DOI: 10.1145/2858036.2858115. URL: http://doi.acm.org/10.1145/2858036.2858115.

[19] Pavel Kucherbaev et al. "ReLauncher: Crowdsourcing Micro–Tasks Runtime Controller". In: *Proceedings of the 19th ACM Conference on Computer–Supported Cooperative Work & Social Computing*. CSCW '16. New York, NY, USA: ACM, 2016, pp. 1609–1614. ISBN: 978–1-4503–3592–8. DOI: 10.1145/2818048.2820005. URL: http://doi.acm.org/10.1145/2818048.2820005.

[20] Edith Law et al. "Curiosity Killed the Cat, but Makes Crowdwork Better". In: *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*. CHI '16. New York, NY, USA: ACM, 2016, pp. 4098–4110. ISBN: 978–1-4503–3362–7. DOI: 10.1145/2858036.2858144. URL: http://doi.acm.org/10.1145/2858036.2858144.

[21] Min Kyung Lee et al. “Working with Machines: The Impact of Algorithmic and Data–Driven Management on Human Workers”. In: *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems*. CHI ’15. New York, NY, USA: ACM, 2015, pp. 1603–1612. ISBN: 978–1-4503–3145–6. DOI: 10.1145/2702123.2702548. URL: http://doi.acm.org/10.1145/2702123.2702548.

[22] Ioanna Lykourentzou et al. “Personality Matters: Balancing for Personality Types Leads to Better Outcomes for Crowd Teams”. In: *Proceedings of the 19th ACM Conference on Computer–Supported Cooperative Work & Social Computing*. CSCW ’16. New York, NY, USA: ACM, 2016, pp. 260–273. ISBN: 978–1-4503–3592–8. DOI: 10.1145/2818048.2819979. URL: http://doi.acm.org/10.1145/2818048.2819979.

[23] David Martin et al. “Being a turker”. In: *Proceedings of the 17th ACM conference on Computer supported cooperative work & social computing*. ACM. 2014, pp. 224–235.

[24] Brian McInnis et al. “Taking a HIT: Designing Around Rejection, Mistrust, Risk, and Workers’ Experiences in Amazon Mechanical Turk”. In: *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*. CHI ’16. New York, NY, USA: ACM, 2016, pp. 2271–2282. ISBN: 978–1-4503–3362–7. DOI: 10.1145/2858036.2858539. URL: http://doi.acm.org/10.1145/2858036.2858539.

[25] Michael Nebeling et al. “WearWrite: Crowd–Assisted Writing from Smartwatches”. In: *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*. CHI ’16. New York, NY, USA: ACM, 2016, pp. 3834–3846. ISBN: 978–1-4503–3362–7. DOI: 10.1145/2858036.2858169. URL: http://doi.acm.org/10.1145/2858036.2858169.

[26] Edward Newell and Derek Ruths. “How One Microtask Affects Another”. In: *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*. CHI ’16. New York, NY, USA: ACM, 2016, pp. 3155–3166. ISBN: 978–1-4503–3362–7. DOI: 10.1145/2858036.2858490. URL: http://doi.acm.org/10.1145/2858036.2858490.

[27] Gabriele Paolacci, Jesse Chandler, and Panagiotis G Ipeirotis. “Running experiments on amazon mechanical turk”. In: *Judgment and Decision making* 5.5 (2010), pp. 411–419.

[28] Alexander J. Quinn and Benjamin B. Bederson. “Human Computation: A Survey and Taxonomy of a Growing Field”. In: *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. CHI ’11. New York, NY, USA: ACM, 2011, pp. 1403–1412. ISBN: 978–1-4503–0228–9. DOI: 10.1145/1978942.1979148. URL: http://doi.acm.org/10.1145/1978942.1979148.

[29] Daniela Retelny et al. “Expert Crowdsourcing with Flash Teams”. In: *Proceedings of the 27th Annual ACM Symposium on User Interface Software and Technology*. UIST ’14. New York, NY, USA: ACM, 2014, pp. 75–85. ISBN: 978–1-4503–3069–5. DOI: 10.1145/2642918.2647409. URL: http://doi.acm.org/10.1145/2642918.2647409.

[30] Joel Ross et al. “Who Are the Crowdworkers?: Shifting Demographics in Mechanical Turk”. In: *CHI ’10 Extended Abstracts on Human Factors in Computing Systems*. CHI EA ’10. New York, NY, USA: ACM, 2010, pp. 2863–2872. ISBN: 978–1-60558–930–5. DOI: 10.1145/1753846.1753873. URL: http://doi.acm.org/10.1145/1753846.1753873.

[31] Niloufar Salehi et al. “We Are Dynamo: Overcoming Stalling and Friction in Collective Action for Crowd Workers”. In: *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems*. CHI ’15. New York, NY, USA: ACM, 2015, pp. 1621–1630. ISBN: 978–1-4503–3145–6. DOI: 10.1145/2702123.2702508. URL: http://doi.acm.org/10.1145/2702123.2702508.

[32] Six Silberman. *Stop citing Ross et al. 2010, “Who are the crowdworkers?"*. Mar. 2015. URL: https://medium.com/@silberman/stop-citing-ross-et-al-2010-who-are-the-crowdworkers-b3b9b1e8d300.

[33] Ryo Suzuki et al. “Atelier: Repurposing Expert Crowdsourcing Tasks As Micro–internships”. In: *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*. CHI ’16. New York, NY, USA: ACM, 2016, pp. 2645–2656. ISBN: 978–1-4503–3362–7. DOI: 10.1145/2858036.2858121. URL: http://doi.acm.org/10.1145/2858036.2858121.

[34] *TaskRabbit connects you to safe and reliable help in your neighborhood*. Sept. 2015. URL: https://www.taskrabbit.com/.

[35] *Uber*. Sept. 2015. URL: https://www.uber.com/.

[36] Shao-Yu Wu, Ruck Thawonmas, and Kuan-Ta Chen. “Video Summarization via Crowdsourcing”. In: *CHI ’11 Extended Abstracts on Human Factors in Computing Systems*. CHI EA ’11. New York, NY, USA: ACM, 2011, pp. 1531–1536. ISBN: 978–1-4503–0268–5. DOI: 10.1145/1979742.1979803. URL: http://doi.acm.org/10.1145/1979742.1979803.

[37] Lixiu Yu, Aniket Kittur, and Robert E. Kraut. “Encouraging “Outside–The–Box” Thinking in Crowd Innovation Through Identifying Domains of Expertise”. In: *Proceedings of the 19th ACM Conference on Computer–Supported Cooperative Work & Social Computing*. CSCW ’16. New York, NY, USA: ACM, 2016, pp. 1214–1222. ISBN: 978–1-4503–3592–8. DOI: 10.1145/2818048.2820025. URL: http://doi.acm.org/10.1145/2818048.2820025.

[38] Alvin Yuan et al. “Almost an Expert: The Effects of Rubrics and Expertise on Perceived Value of Crowdsourced Design Critiques”. In: *Proceedings of the 19th ACM Conference on Computer–Supported Cooperative Work & Social Computing*. CSCW ’16. New York, NY, USA: ACM, 2016, pp. 1005–1017. ISBN: 978–1-4503–3592–8. DOI: 10.1145/2818048.2819953. URL: http://doi.acm.org/10.1145/2818048.2819953.

[39] M. C. Yuen, I. King, and K. S. Leung. “A Survey of Crowdsourcing Systems”. In: *Privacy, Security, Risk and Trust (PASSAT) and 2011 IEEE Third Inernational Conference on Social Computing (SocialCom), 2011 IEEE Third International Conference on*. Oct. 2011, pp. 766–773. DOI: 10.1109/PASSAT/SocialCom.2011.203.