A REVIEW OF PIECEWORK

The HCI community has used the term "piecework" to describe myriad instantiations of on–demand labor, but researchers have generally made this allusion in passing. Since this paper traces a much stronger parallel between (historical) piecework and (contemporary) crowd work (and, more generally, on–demand labor), a more comprehensive background on piecework will be useful. We will more carefully discuss piecework in this section to help make our observations and arguments with better familiarity with the topic. Specifically, first, we'll define "piecework" as researchers in its field understand it; and second, we'll trace the rise and fall of piecework at a high level, identifying key figures and ideas during this time. This section is not intended to be comprehensive: instead, it sets up the scaffolding necessary for our later investigations of crowd work's three questions: complexity limits, task decomposition, and worker relationships.

What is piecework? A Primer and Timeline

Aligning on–demand work with piecework requires an understanding of what piecework is. While it has had several definitions over the years, we can trace a constellation of characteristics that recur throughout the literature. We'll follow this research, collecting descriptions, examples, and definitions, tracing an outline of *what piecework is* alongside piecework's contemporary developments in practice.

Piecework's history traces back further perhaps than most would expect. Grier describes the process astronomers adopted of hiring young boys to calculate equations in order to better–predict the trajectories of various celestial bodies in the 1830s [12]. George Airy was perhaps the first to rigorously apply piecework–style decomposition of tasks to work; by breaking complex calculations into constituent parts, and training young men to solve simple algebraic problems, Airy could distribute work to many more people than could otherwise complete the full calculations.

Piecework may have started in the intellectual domain of astronomical calculations and projections, but it found its foothold in manual labor. Piecework took hold in farm work [26], in textiles [1, 27], on railroads [4], and elsewhere in manufacturing [30]. Fordism and scientific management thrust piecework into higher gear, especially as mass manufacturing and a depleted wartime workforce forced industry to find new ways to eke out more production capacity. [MSB: I think a sentence here to characterize the height of piecework would be helpful — how big a deal was it at its peak?] [al2: I'm not sure; I'll look for some data.

update: hard to find anything saying "piecework represented eleventy billion dollars of the U.S. economy", which is what I'd like to say, but I can say something like "at its height, *k%* of garment workers were pieceworkers" or something. that seems a bit wishy–washy though; I'd like to say something like "*k%* of the *entire U.S. workforce* was working under some sort of piecework regime".]

By 1847 we find a concise definition of piecework in Raynbird's essay (where he also calls piecework "measure work", "grate work", and "task work"), particularly driven toward encapsulating the manual labor of farmwork. Raynbird does this by contrasting with the "day–labourer" — "the chief difference lies between the day–labourer, who receives a certain some of money … for his day's work, and the task–labourer, whose earnings depend on the quantity of work done" [26]. Chadwick defines it through examples: "payment is made for each hectare which is pronounced to be well ploughed … for each living foal got from a mare; … for each living calf got" [7]. This framing offers a more intuitive sense; "payment for results," as he calls it, is not only common in practice, but well–studied in labor economics as well [11, 32, 33, 16].

It's worth acknowledging that "this distinction [between piece–rates and time–rates] was not completely clear–cut" [15]. Indeed, employers adopted piece–rate compensation in some aspects and time–rate compensation in others. The Rowan premium system, which essentially paid workers a base rate for time plus, potentially, an additional pay dependent on output [29]; this was just one of several alternatives to categorical time– and piece–rate renumeration paradigms. As Rowan's premium system guaranteed an hourly rate regardless of the worker's productive output *as well as* additional compensation tied to performance, workers under this regime were in some senses "task–labourers", but in other senses "day–labourers".

It may be worth thinking about piecework through the lens of its *emergent* properties to help understand it. Raynbird argues for the merits of piecework, pointing out that "piece work holds out to the labourer an increase of wages as a reward for his skill and exertion … he knows that all depends on his own diligence and perseverance … [and] so long as he performs his work to the satisfaction of his master, he is not under that control to which the day–labourer is always subject". The argument that "task–labourers" enjoy freedom from control crops up in Raynbird's and later Rowan's works [26, 29].

We see this sense of independence in myriad times, locales, and industries. Satre offers a look into the lives and culture of "match–girls" — young pieceworkers, mostly women, who assembled matchsticks in the late 19th century. Of interest was their reputation "… for generosity, independence, and protectiveness, but also for brashness, irregularity, low morality, and little education" [30]. Hagan and Fisher document piecework from 1850 through 1930 in Australia, finding similar notions of independence and autonomy among piecework newspaper compositors: "If a piece–work compositor … decided that he did not want to work on a particular day or night, the management recognised his right to put a 'substitute' or 'grass' compositor in his place" [13]. This sense of independence and autonomy appears to be an inherent component of piecework.

[al2: I think now that this is moved to this area there's a good opportunity to frame this more as "now that workers could choose their own schedule, style, etc…, newfound interest in how to manage these workers emerged". Thoughts?] The early growth of piecework led to discussion on how best to manage pieceworkers, generally regarding workers antagonistically [24, 8]. This was a far cry from the earlier rhetoric on piecework, which promised that piece workers would gladly work as diligently and as hard as possible because incentive–based pay would reward workers directly for hard work [].

Piecework opened the door for people who previously couldn't participate in the labor market to do so, and to acquire job skills incrementally. During World War II, women received training in narrow subsets of more comprehensive jobs, enabling work in capacities similar to conventional (i.e. male) workers [15]. Workers with specific skill subsets could be matched to suitable tasks. Women previously had virtually no opportunities to engage in engineering and metalworking apprenticeships as men did; now, they could be trained quickly on narrowly scoped tasks, demonstrate proficiency, and become experts.

Piecework's popularity in the United States and Europe plummeted almost as quickly as it had climbed. Between 1938 and 1942, piecework in a number of metal workers had climbed as steeply as from 11% to 60% [14]; by 1961, that proportion dropped to as little as 8% [6]. Carlson details that, from 1973 to 1980, the remaining bastions piecework — where more than 50% worked under incentive wage plans — were principally in clothes–making (e.g. hosiery, footwear, and garments). Hart and Roberts's work substantively explores the precipitous decline of piecework in the last third of the 20th century.

[al2: ", ultimately arguing that…"?]

In summary, piecework: 1) paid workers for quantity of work done, rather than time done, but occasionally mixed the two payment models 2) afforded workers freedom in when and how much to work 3) structured tasks such that people who didn't have the training to engage in the traditional labor force could still participate.

Viewing crowd work as a modern instantiation of piecework is relatively straightforward by this definition. First, platforms such as Mechanical Turk, Uber and TaskRabbit pay by the task, though some such as Upwork do offer hourly rates as well. Second, workers are attracted to these platforms by the freedom they offer to pick the time and place of work [21, 3]. Third, system developers as on Mechanical Turk typically assume no professional skills in transcription or other areas, and attempt to build that expertise into the work flow [23, 2]. Given this alignment, many of the same properties of piecework historically will apply to on–demand work as well.

Case studies in piecework

Throughout the rest of the paper, we will return to three major case studies to frame our analyses: railroad and other industrial workers; Airy's employment of *human computers*; and domestic and farm work (in particular, the "match–girls"). We'll introduce the facts of these three cases, beginning with the most familiar case of piecework — industrial work, such as assembly line manufacturing — working backwards through the 20th and 19th century. In doing so, we'll trace the history of piecework while also framing the later analysis of the major research threads we named earlier (questions toward complexity, decomposition, and relationships, respectively).

[al2: I'm coming out of this with a sort of structure that *loosely* describes piecework chronologically. Strictly speaking, I'm talking about each of these topics (let's call them **human computation**, **domestic and farm work**, and **industrial work**), and some of these things overlap with each other to some extent, but for the most part Airy and the human computers came in the mid–19th century, farm work and the "domestic" work (like making matches) came around at the turn of the 20th century, and the industrial work (railroad workers, the WWII war effort, and the rise of the labor union movement) unfolded from the early 20th century onward.]

Railroad and other Industrial Workers

Piecework might be most familiar to the HCI researcher in the context of the assembly line, which largely defined manufacturing through the 20th century. It was here that scientific management, Fordism, and Taylorism dramatically influenced how workers were managed and the ways in which workers were perceived and envisioned paradigmatically; it's here we'll start our overview of piecework's history through case studies. [MSB: we're not starting an overview of history; aren't we midway through it?]

[MSB: I'm feeling very disoriented in this paragraph. The subsection title is about railroads, but we're all fast-forwarded to auto manufacturing?] Piecework through the 20th century centered around auto and other mass manufacturing, but found its way into the war effort during World War II. With the vast majority of men drafted into service, factories found themselves turning to a predominantly female workforce that had neither the formal training nor the years of apprenticeship experience that conventional workers would have had. Rather than attempting to train this new labor force in every aspect of industrial work, these women were trained for individual tasks and assigned to that task. One might reflect on the observation that "Rosie the Riveter", an icon of 20th century America who represented empowerment and opportunity for women [17], was a pieceworker [9].

[MSB: confusing timing; now we're going backwards?] With Taylor's formalization of scientific management in *Taylorism* (and Henry Ford's eponymously named *Fordism*), piecework in the early and mid–20th century surged, especially in industrial work. Scientific management promised that the careful measurement of workers would yield higher efficiency and output [31, 20]. While Brown points out that piecework dramatically advanced the instrumented measurement of workers, in Taylor's time highly instrumented, automatic measurement of workers was all but impossible [4]. Instead, managers conducted "stop watch time studies" [22], using completion times to inform per–task compensation.

[MSB: even further backwards??? I would have expected this section to take a time slice and tell me about one group of people in detail] [MSB: this content might go above in the paragraph about the heydey of piecework in the piecework review] The 1930s represented a boom for piecework on an unprecedented scale, especially among engineering and metalworking industries. Hart and Roberts characterize the 1930s — and more broadly the first half of the 20th century — as the "heyday" of the use of piecework. They attribute this to the shortage of male workers, who would have gone through a conventional apprenticeship process affording them more comprehensive knowledge of the total scope of work.

[MSB: This subsection feels like it never delivered on what it promised: a case study of one group of pieceworkers. I

thought the goal was to introduce the railroad workers — who they were, what they did, what their conditions were like.]

Domestic and Farmhand Labor

When piecework entered the American economy, it was not used for complex work. One reason for low complexity was workers' skills: it was infeasible to provide new pieceworkers with the comprehensive education that apprenticeships imparted [15]. So, initially piecework in the United States arose for farm work, and as Raynbird and others discuss, the practice remained relatively obscure until it blossomed in the textile industry [26]. [MSB: this is not about domestic/farmhand labor...might need to move up or be cut...or is it? clarify that this is domestic labor moving into NYC?] The complexity of the work remained low at the turn of the 20th century as piecework saturated New York City [27]. [MSB: how is this sentence relevant to the case study?:] However, writers of the time focused their attention on wage [5] and management regimes [24] rather than training. Mass manufacturing, such as sewing garments [27] and making matchsticks [30], flourished under piecework systems in densely populated cities.

Workers' relationships with employers quickly soured. [MSB: We haven't met the match–girls yet. Is this case study supposed to be about them? They come out of nowhere, and we're talking about their strike rather than them.] The match–girls strike of 1888 was one of the earliest and most famous successful worker strikes, and perhaps the beginning of "militant trade unionism" [30]. As Weyer, Webb, and Webb described, "the match–girls' victory turned a new leaf in Trade Union annals" [34]: in the 30 years after the match–girls strike, the Trade Union Movement enrollment grew from 20% of eligible workers to over 60%.

The match–girls strike foreshadowed both collective action victories and an emerging paradigm regarding worker management. [MSB: this paragraph seems to be about collective action rather than domestic/farmhand labor. also, coal miners aren't domestic or farmhand.] Coal miners won a nationwide individual minimum wage after The Great Coal Strike of 1912 [28]. Garment workers in Philadelphia secured collective bargaining rights in 1915 after a prolonged strike and threat of a second [10]. [MSB: Why is Taylor relevant to this case study?] [al2: I'm just clumsily interleaving the contemporary literature with the events. I'd like to say "This is the geist of work in their time"; is this a bad idea?] It was in the midst of this time that Taylor published the work for which he would later be called "the father of scientific management" [19]. It was this framing on work & worker management that gave workers a concrete adversary — if not Taylor, then *Taylorism* — against which to rally [18, 25].

Airy's Computers

[MSB: This one seems way thinner than the others? Maybe it should be merged with the earlier description of Airy.] Some of the first systematic cases of what we would recognize as crowd work can be found in the study of astronomy. In the 19th century, the calculation of celestial bodies had become a competitive field with Airy needed to compute tables that would allow sailors to locate themselves by starlight from sea. This work ostensibly called for educated people who comprehensively understood mathematics. Airy realized that he could break the tasks down and delegate the constituent parts to "human computers" who "… possessed the basic skills of mathematics, including 'Arithmetic, the use of Logarithms, and Elementary Algebra' " [12]. As a result, many of Airy's computers had relatively rudimentary educations compared to the background of education that typically worked in the calculation of solar tables. Airy distributed tasks by mail, allowing work to be completed by a somewhat geographically distributed workforce, and paid for each piece of work completed. Airy also instituted a policy of firing his computers once they reached age 23 [al2: this has a "gosh isn't that interesting?" feeling to it. should i just leave it out until later when there's something to say about it (namely, that the mode of work was initially designed to stymie professional growth)?].

[al2: This should go later someplace, but not clear where:

This practice ensured two outcomes that arguably disfavored workers. First, it eliminated any potential to advance professionally, as workers' careers in this area ended relatively early in their careers, and without formal education in mathematics they struggled to find work for which their experience was meaningful. Second, it limited workers' ability to organize by ensuring that workers hardly spent sufficient time to successfully rally their peers.]

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