

### **Graduate Research Plan Statement**

**Background:** The rapid growth of the gig economy has motivated freelancers around the globe to engage in more flexible and autonomous forms of work. Digital labor platforms offer workers novel job opportunities, enable small businesses to quickly meet labor demands, and provide services like ridesharing and food delivery to individual consumers. In 2020 alone, studies have shown that the pandemic fueled a 33% growth in wages and participation of gig workers [1].

On the surface, short-term contractual work arrangements promise independent freelancers a unique means of earning income - one that gives workers the agency to choose when, where, and how much to work, without the hassles of formal onboarding. But in reality, the amalgamation of low compensation, high competition, and the just-in-time nature of gig work means that individual contractors (especially those who depend on freelancing for primary income) must toil at odd hours for prolonged periods of time with minimum compensation just to remain competitive and make a living. Such negative impacts on worker wellbeing may magnify existing discriminations against marginalized groups like racial and gender minorities, raising substantial amounts of societal, legal, and scholarly concern. Hiring platforms' compulsorily use of gender- and race-insensitive algorithms further aggravate unfair distribution of work opportunities across population segments [2].

**Research plan:** In this proposed study, I plan to uncover worker challenges, stakeholder needs and develop necessary digital infrastructure to create a more equitable, inclusive and empowering environment for gig workers. The formation of such a system may provide workers with necessary social, technological and policy support to develop a fairer, healthier and more collaborative gig community so that freelancers can thrive in this new world of work.

- **RQ1:** *How do various gig worker strategies (e.g. length of time worked, bid prices, portfolio management, communication patterns, flexibility in scheduling) affect measures of well-being such as hiring and completion rates, financial stability as well as overall senses of fulfillment and career development?* Some of our preliminary work (submitted to CHI 2022) revealed that strategies such as 1) personalizing bid application text, 2) keeping fixed messaging schedules and 3) bidding to more projects may contribute to worker productivity and revenue.
- **RQ2:** *In what ways do biases manifest within online labor markets? To what extent are they affected by client discrimination and amplified by platform designs?* My recent investigations with a labor platform, among other studies [3], have shown the presence of gender and racial biases within the gig economy, as well as correlations of gender gaps with factors like geography.
- **RQ3:** *What interventions, tools, and bias mitigation strategies would workers most prefer for fostering a more cooperative, equitable and thriving community?* Using empirical results from R1 and R2, we can survey the requirements and preferences of various community members (e.g. workers, consumers, and platform managers) to inform the design of interventions and tools to enhance worker wellbeing.
- **RQ4:** *What design recommendations and fairness checklists can we provide platform designers to create more equitable, and sustainable online labor markets? How can shifts in online labor participation impact the offline economy?* The various interventions, features, and mitigation strategies that different user groups generate may complement or conflict with one another. As platforms prepare for a diverse range of target users, they must periodically re-evaluate existing designs and algorithms to ensure that their approaches are fair and offer positive outcomes for both online and offline labor markets.

**Resources:** In addition to connections I formed with employees from a leading labor market as a research consultant, collaborators have granted us access to data from one other major online freelancing platform. Local policymakers such as the Allegheny County's Department of Economic Development and the City of Pittsburgh Department of Innovation and Performance has also expressed intent to collaborate and provide resources, allowing us to investigate offline effects of the gig economy's growth - local unemployment has been observed to interact with an online market's labor supply in a past study.

- **Year 1:** In the first six months, I will validate and extend our past empirical work on communication patterns with qualitative studies to pinpoint both platform-specific and generalizable strategies for improving various success measures of gig workers. Following that, I plan to spend the next six months collaborating with industry partners to quantify and uncover implicit gender and racial biases of platforms, as well as develop strategies for mitigation. This summer, I began this effort at a leading online labor platform, where I established fairness metrics and measured the impacts of models on bidding and hiring behaviors across different genders. I intend to continue this exploration for a wider range of platforms and disadvantaged groups.
- **Year 2:** After gaining an initial understanding of existing biases, we plan to leverage the empirical findings to co-design and develop a set of tools, policies, and checklists with gig workers, platform designers, legal experts, and local policymakers to improve worker well-being and promote fairer practices among platform and algorithm designers. In particular, we will focus on changing existing models to protect vulnerable populations for whom workplace discrimination is prevalent, including gender and racial minorities, as well as persons with disabilities.
- **Year 3:** Using the results from our quantitative analysis and co-design workshops, we will develop prototype systems and interventions and consider collaborating with platforms to deploy them. Alternatively, we will also consider the development of meta-platforms or support systems that are independent of existing online labor platforms.

**Intellectual Merit:** This proposed study seeks to contribute to the growing literature on freelancing by 1) investigating current worker needs, practices, and goals over the short and long terms 2) conducting co-design workshops with relevant stakeholders from various gig platforms to envision and plan fairer, healthier and more collaborative communities, and 3) implementing and iteratively improving prototypes of the community support system.

**Broader Impacts:** The various roadblocks present in the gig economy impacts heavily on vulnerable populations such as women, who are responsible for most of the unpaid caretaking around the world, but are still subjected to unpredictable scheduling and long hours. Even for digitally-mediated work, recent studies have shown that women underbid (at a rate larger than BLS's reported national wage differences), but earned more over time - implying they worked longer hours to make up for the gender gap [3]. My work will address these growing societal issues by contributing to the discovery and mitigation of existing biases against vulnerable populations. Our collaborations with industry partners may enable interventions and innovations to be embedded within current gig platforms, which has the potential to positively impact tens of millions of workers across the globe.

## References

[1] Karra. *The Gig Or Permanent Worker: Who Will Dominate The Post-Pandemic Workforce?*(2021) [2] Leung et. al. *Race, Gender and Beauty: The Effect of Information Provision on Online Hiring Biases* (2020) [3] Foong et. al. *Women (Still) Ask For Less*. Proc Acm Human-computer Interact (2018).

### **Personal, Background, and Future Goals Statement**

**Motivation:** Preceding the pandemic-induced global shutdown, I signed up for a student-led, experimental course to develop curricula and teach English and citizenship classes to immigrants at *El Centro de Servicios Sociales* - a nonprofit organization serving Lorain county's Latinx population. Having a working knowledge of Spanish and experiences TA-ing for a language course, the volunteer initiative presented an ideal opportunity to combine my interests in language pedagogy and serving the immigrant community. While the lockdown prevented us from physically participating in community engagement, we gained much perspective and understanding by talking to the director of *El Centro* about its mission, exchanging immigration stories, and even sending out concerned citizen letters to our own community members to broadcast the current state immigration events. In writing the letter, I started reflecting on and developing a concern for how essential (gig) workers, largely composed of immigrants at the time, risked their lives to meet our delivery and transportation needs, but received no employee insurance or protections. Even though my own immigration story began earlier on during elementary school, previous generations' grueling tales and current journeys of friends from various international origins constantly remind me of the struggles involved in pursuing the American dream. As a 1.5 generation immigrant, I was driven to improve the wellbeing and working conditions of gig workers, to ease their transitions so that they can better navigate and thrive in their new surroundings. Upon entering my PhD program last fall, I was fortunate enough to have the opportunity to join Professor Haiyi Zhu in exactly this endeavor.

**Research Background:** My interest in supporting marginalized communities may have originated from my first research experience: the STRONG program at Oberlin annually selects a cohort of minorities and traditionally underrepresented scholars from the accepted body of students to participate in mentored, pre-college research. During this summer, I devolved into materials science research under the guidance of Prof. Yumi Ijiri, where we worked on the separation of iron oxide nanoparticles. Given its wide variety of uses in data storage, water contamination and biomedical science, I was thrilled to design prototype channels, prepare abstracts and present posters to contribute to the advancement of the research. Even though this project fell in the domain of experimental physics rather than computer science, it gave me the chance to understand and contribute to the improvement of an existing system, as well as hone my problem-solving and collaboration skills. The cohort of intelligent, motivated scholars I met and worked with during this program has also been an indispensable source of support as we continued our various pursuits in academia and beyond.

Inspired by this community of driven diligent individuals and the superb mentorship from Prof. Ijiri and members of the lab, I continued taking a role within the research group the following summer, but this time with more computational focus. Using Jupyter notebooks and command-line tools, I analyzed a series of experimental results from polarization-analyzed small-angle neutron scattering applied to manganese ferrite nanoparticles under 12 different conditions. We fitted this dataset to a C++ model to learn about the particles' structural and magnetic properties and inter-particle interactions across various magnetic fields and temperatures. To enlarge our search space and optimize for efficiency, I wrote scripts to automate parameter tuning for the model, revealing novel trends in the nanoparticles' clustering behavior. At the Ohio College Summer Research Symposium, I gave a talk on some initial findings of the work, and the results eventually culminated in a publication at the top-tier journal *Physics Review B*. During the process, I developed a vested interest in creating shortcuts, macros and schemas to optimize for usability, organization and efficiency, guiding me toward the realm of human-centered computing and interface design.

Motivated by my own explorations as a data scientist, I sought opportunities to learn more ways of improving the workflows of programmers. So in the summer after my sophomore year, I joined the Natural Programming Group at CMU to work on UNAKITE, a tool designed to help developers make and document decisions when coding. The Chrome plugin (built in ReactJS) was an interface implementation of the *comparison table* – a visual model that supports information collection and decision making by tabulating relevant problem solutions and requirements. To evaluate the model's usability, I assessed its adaptability to a varied sample of 200+ Stack Overflow questions and found more than half of answer posts to be amenable to the tabulated visualization format. I published and presented these findings through an extended abstract and poster at the 2018 VL/HCC symposium. Based on some initial usability testing, I implemented improvements to UNAKITE, and subsequently ran user studies on the system to gather user feedback and gauge the tool's scalability. Through this project I learned to individually present findings and utilize methods such as scenario-based design, interface implementation, sampling techniques, and user testing to iterate on and refine an existing system. Over the next year, I continued these investigations through remote collaboration with the UNAKITE group and Prof. Cynthia Taylor, where we formally evaluated the system by designing and conducting user studies, qualitatively coding results from 16 participants and measuring our inter-rater reliability with intraclass correlation as the standard of measurement. We observed a 45% improvement (measured by reduction in overhead cost) in a programmers' ability to understand tradeoff-related technical problems and solutions with the aid of UNAKITE and submitted these findings to the 2019 UIST conference, where our work received a best paper honorable mention.

My time with researching programming support tools taught me many principles and techniques of design thinking and usability testing, and in the summer after my third year, I had the opportunity to apply them toward a real-world problem that many engineers encounter: operators of large-scale, multicloud Kubernetes applications must navigate through an excess of resources and dashboards when triaging issues or monitoring traffic, which can slow down troubleshooting and prolong outages. To better understand pain points of these target personas, my team worked with members from IBM Cloud Private to reach out and conduct extensive user research with multicloud application managers within the company. Through in-depth interviews and walkthroughs, we unveiled critical insights and pain points that guided our end-to-end development, testing, and enhancements of a terminal-based tool. Built with the Python curses library, our solution leveraged an intuitive tree-style navigational structure and fuzzy search to display hierarchy, highlight anomalous behaviors, and facilitate quicker detection of problematic resources. The terminal UI was open sourced for public use, and our idea of a cross-cloud anomaly detection system is now protected through a defense publication.

After honing my skills in user research and system implementation in a real-world development context, I felt ready to contribute toward an effort that was brought to my awareness a summer before: reducing hostility toward newcomers in online programming communities. At the time I started my honors thesis, 30% of posts on Stack Overflow (SO) were left unanswered, signaling a need for better-constructed questions. To further understand of answerers' needs, I sampled questions using the Stack Exchange Data Explorer and applied a two-proportions z-test to identify three critical factors characteristic of most successful questions: code snippet inclusion, length, and descriptions of attempted solutions. Using these features, I built a prediction model for answerable questions and embedded it within a dynamic plugin. The construction assistant I implemented uses the model to provide users with a measure of their question answerability, celebrates when good practices are observed, and suggests actionable improvements when one of these features is absent.

**Intellectual Merit:** My multidisciplinary research and industry experiences I have accrued prepared me to work on improving the success and well beings of gig workers. During the past year, I led an effort to empirically investigate communication and bidding strategies utilized by gig workers on a leading online freelancing platform. In the incoming semesters, I plan to extend these findings and combine them with my previously developed skills of system-building, user research and programmer support to design and contribute toward a gig work environment that 1) facilitates and encourages resource sharing among gig workers and 2) reduces bias and discrimination against vulnerable population segments, so as to improve the financial, social and physical well beings of individual workers and contribute toward building more equitable and inclusive platforms and gig communities. Having prior experiences with tool-building and researching newcomer support will help me conduct research more methodically as an NSF Fellow.

For the past five months, I have been working with an industry partner as a research consultant (full-time in the summer and part-time during the semester) on detecting and mitigating biases against vulnerable populations. Given this past work, and the platform's intentions to measure and actively eradicate biases from their features and models, I am optimistic about the prospect of future collaborations to introduce interventions and platform changes for combating biases.

**Broader Impacts:** My research journey began with an experience that cultivated a personal interest in improving end-user programming. Gradually, the target population of my work has grown to include the more general online programming community, application operators, and most recently, gig workers from across the world. In my most recent endeavor contributing to the software engineering community, I lead a team of two undergraduate researchers to qualitatively study toxicity, moderation approaches and bot interactions in open source environments. In the process, I've developed protocols and modularized tasks into manageable chunks so that my mentees can better understand and work with the complex and technical space of open source development. This ability to appropriately scope problems and break them down into achievable tasks will be crucial for completing future goals of my research on the gig economy.

I highly value and appreciate my undergraduate experiences for providing me with the necessary resources for beginning and continuing my career as a researcher. So in addition to mentoring, I try to give back to the community by volunteering with organizations such as the undergraduate research engagement group at Carnegie Mellon. To ensure undergraduates have a chance to learn about research processes and opportunities, we plan, conduct outreach for, and host various events such as research mixers, panels and lab crawls where undergraduates can learn from more experienced graduate students and professors. Even though it was just formed this semester, the committee has gained much traction, with each event attracting hundreds of budding undergraduate researchers.

Teaching for me has the dual goal of helping others understand a topic and elevating my own understanding of a subject. At Oberlin, I thoroughly enjoyed preparing for and holding office hours and recitations for the algorithms course for multiple semesters, in addition to grading and lab helping for a plethora of other classes. I have also served as a leader in Oberlin's SOAR Program (where I supported the careers of prospective computer science students with resources and workshops) as well as in the Uncovering COVID-19 course (a mini that emerged during the lockdown) to help accepted students gain a better understanding of the disease from multiple perspectives while building a virtual community. In my graduate studies and beyond, I aspire to continue the dissemination of knowledge and resources through research and teaching, so that I can impact an even wider community as a mentor and professor.