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A Survey Study on the Technology and Public Acceptance of Remote Labor ⋆

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Abstract: This paper presents a survey study on the concept of remote labor, which aims at allowing employees in labor jobs to work remotely by teleoperating robots over the internet. As a pilot survey, findings of this study can guide the practical implementations of remote labor. Potential benefits of remote labor include improving working conditions, bringing robustness against disastrous events, providing employment opportunities, and accelerating AI development. Nevertheless, remote labor faces some particular technological and social challenges. 218 responses to a questionnaire have been collected to study the public acceptance of remote labor when considering issues on technology readiness, working environment, safety and liability, contracts and compensations, data collection and use, overseas outsourcing, and more. The paper has also reviewed over 50 published articles on related technologies, business models, and regulatory practices.

Keywords: Robot Teleoperation, Labor, Remote Work, Human Computation, Crowdsourcing

1. INTRODUCTION

Over the COVID-19 pandemic, a great number of employees moved to working from home. Remote work has reportedly been an overwhelming success for both employees and employers [PricewaterhouseCoopers (2021)]. While most office workforce can easily transfer to remote work, due to the requirement of onsite presence, employees in labor jobs that involve nontrivial physical actions, such as delivery, construction, manufacturing, and medical service have been left behind. The issue affects not only conventional blue-collar workers, but also freelancing workers who earn income from gig labor jobs, which have become a major form of service delivery [Healy et al. (2017)]. Meanwhile, labor jobs have also been long plagued by demanding work intensity, poor working conditions, lower salaries, and higher safety risks [Maestas et al. (2017)]. The challenges also make it increasingly more difficult to hire and keep employees in labor jobs [Ferguson (2022)].

This paper studies the concept of Remote Labor, which aims at allowing employees to work in labor jobs by remotely controlling robots via the internet (Fig. 1). Serving as surrogate machines instead of autonomous agents, the remotely human-controlled robots could be a robotic vehicle for delivery, a robotic construction machine, nursing or cleaning robots, and more. Other than benefiting conventional employees and employers of labor jobs, remote labor would also create new employment opportunities for people living in remote areas and people with physical disabilities.

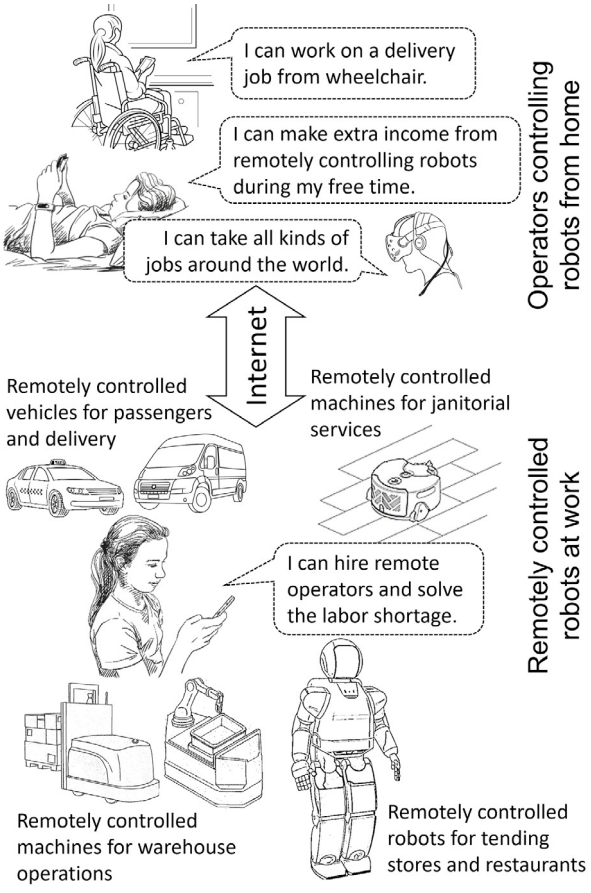

Fig. 1. The concept of Remote Labor

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Remote labor can be considered as a form of Human Computation, which utilizes human intelligence to solve problems that computers cannot yet solve well [Quinn and Bederson (2011)]. Artificial intelligence (AI) technologies are still primitive to power robots to serve human society ubiquitously [Boyd and Holton (2018)]. Human intelligence can be leveraged to work around the bottleneck and bring ubiquitous robotic service to human lives long before AI technologies mature. Meanwhile, a massive amount of sensor and control data can be collected constantly while the robots are teleoperated by humans. The data can be used to develop AI and gradually increase the level of robot physical intelligence, which in turn will relieve humans from real-time control of robots, allowing each operator to simultaneously command multiple robots and scale up productivity. Machine learning based on crowdsourced human computation has achieved great success in applications such as image recognition and language translation [Vaughan (2017)], and is beginning to gain attention in the area of robot physical intelligence [Mandlekar et al. (2018), Forbes et al. (2014), Chung et al. (2014)].

Other than the robotic rovers used in space exploration, applications of long-distance robot teleoperation such as remotely controlled construction machines and remote robotic medical treatments have been discussed for decades [Kebria et al. (2018), George et al. (2018)]. Nevertheless, internet-based robot teleoperation had been commercialized little until recently when telepresence robots became popular on the consumer electronics market. With the boom of high-speed mobile networks, many believe the technologies are almost ready for internet-based remote robotic surgeries [Acemoglu et al. (2020), Meshram and Patil (2020)] and remote driving [Liu et al. (2017), Saeed et al. (2019)].

Despite the technology readiness, little has been studied on the public acceptance of widespread use of internet-based teleoperated robots, especially for changing how labor jobs are conducted - i.e., the concept of Remote Labor. This paper examines over 200 responses to a questionnaire on remote labor and discusses a wide range of related issues, including safety and liability concerns, working environment, expectations of salary and benefits, contracts and unionization, data use and privacy, overseas outsourcing, and more. In addition to studying the questionnaire responses, this paper also presents a literature review on related technologies and social issues.

2. QUESTION DESIGN AND DATA COLLECTION

A total of 218 anonymous participants have been asked to answer a questionnaire of nine questions related to the concept of remote labor. 8 out of the 218 responses are incomplete while none is invalid. The responses were collected in December of 2021, by when the COVID-19 pandemic had lasted for two years. Lives have been significantly changed by lockdowns and remote work, making the survey more related than if held before the pandemic. All participants are students enrolled at New Jersey Institute of Technology in the US, with 83% from undergraduate programs (mostly domestic students) and the rest from graduate programs (mostly international students on the F-1 visa). With the shift to remote learning, students are among the ones most substantially impacted by the pandemic and could provide thoughtful answers. As a measure of financing their college study, many of the students have worked labor jobs and can well relate to the issues prompted in the questionnaire. Meanwhile, the higher education they are receiving helps them accurately picture the envisioned technology. With a combination of these factors, responses from the group can shed unique insights before more responses can be confidently collected from the general public.

The questionnaire starts by asking the participants to specify if they have worked certain types of labor jobs, including both formally employed positions such as construction machine operator as well as freelance jobs such as child or pet sitter. The second question asks about experience with video games, which often share similar control interfaces with robot teleoperation. Then, the concept of remote labor is explained. Giving the introduction after the first two questions helps the participants better relate to the concept. Question 3 asks how interested the participants are in working remote labor jobs as described, and asks about their concerns. Question 4 asks how the participants favor working from home as opposed to from an operating center near home. Question 5 checks the participants' expectation on salary and benefits of remote labor jobs. Question 6 checks if the participants are open to being hired as freelancers in remote labor jobs, as well as how they would care about unionization. Question 7 inquires about data collection and use. Question 8 asks for opinions on outsourcing remote labor jobs to overseas. Question 1 to 8 are single- or multi-selection questions. Finally, question 9 asks for additional open opinions.

3. QUESTIONNAIRE RESPONSES

3.1 Experience in labor jobs

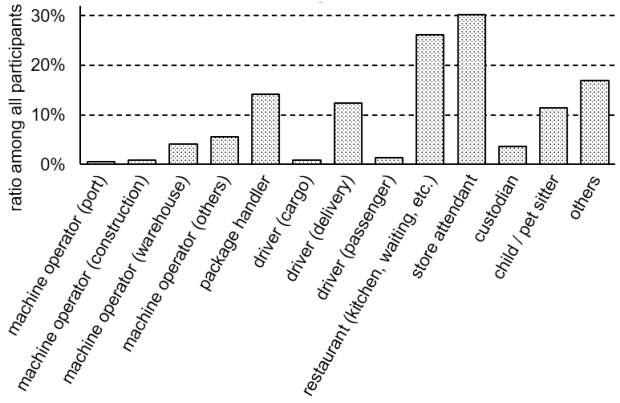

Fig. 2. Ratios of participants who have worked labor jobs

72.0% of the participants have done one or more types of popular labor jobs, while 30.7% have done two or more types (Fig. 2). Many would assume that those who have done labor jobs would be more open to remote labor. However, the data indicate the other way (Fig. 3). 15.9% of those who have done labor jobs say they would not consider any remote labor jobs, while only 4.9% of those who have no experience in labor jobs say the same. (Note that in order to show the differences clearly, disapproval rates are used.) 26.8% of who have done labor jobs say they

would not do remote labor jobs if the salary were lower than their onsite peers, while a lower rate of 21.3% is found among those who have no experience in labor jobs. 41.4% of those who have done labor jobs say they would not do remote labor jobs if the benefits were lower than their onsite peers, compared to 36.1% among those who have no experience. Similar but not as significant differences have been observed when the participants are asked about contracts and unionization.

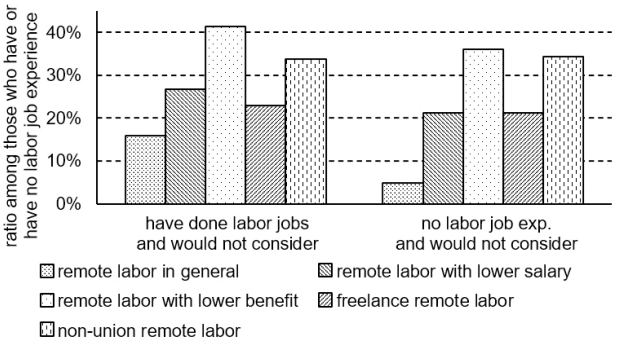

Fig. 3. Ratios of participants who would not consider remote labor jobs among those who have or have no experience in labor jobs

It is actually common for people who have occupational experience to be skeptical towards new technologies in their areas. For example, most surgeons are skeptical towards automated robotic surgeries [Gumbs et al. (2021)]. Manufacturers in certain areas are conservative towards adopting 3D printing [Price et al. (2021)]. Educators have voiced resistance to shifting to online teaching [Rasheed et al. (2020)]. In addition, the survey participants are all college and graduate students, many of whom seek higher education to obtain employment opportunities other than labor jobs and their preference could be biased accordingly.

The participants' experience in labor jobs is further labeled by four particular features:

- MO: involving professional operation of machines (not including vehicles),
- DV: involving driving vehicles (including cargo, passenger, and delivery vehicles),
- OH: requiring handling a variety of objects - e.g., package handler, delivery driver, food service worker, store attendant, custodian, child/pet sitter.
- PI: requiring professional interaction with persons - e.g., restaurant staff, store attendant, child/pet sitter.

More than one label can apply to the same participant. As shown in Fig. 4, participants with experience of driving vehicles in labor jobs are considerably more interested in remote labor jobs and are willing to consider a salary lower than their onsite peers. The pattern could be explained by the participants' impression of technology readiness. Assisted/automated driving and remote vehicle functions enabled by mobile networks are among the most discussed consumer technologies on media. Driving simulation is one of the most popular video game genres. Such factors make people consider remote driving to be of a much higher technology readiness than other applications of remote labor.

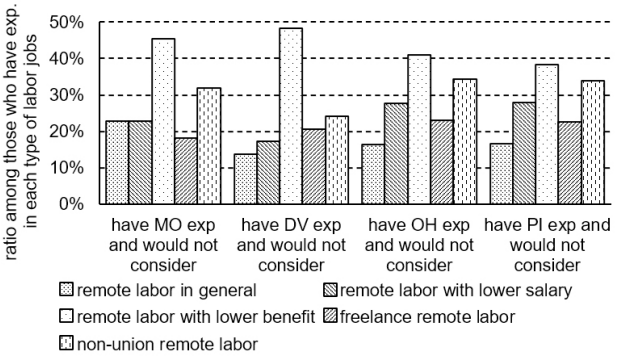

Fig. 4. Ratios of participants who would not consider remote labor jobs among those who have done certain types of labor jobs

3.2 Experience with video games

Among the 218 participants, 47.7% play video games regularly, 29.8% play occasionally, 13.8% used to play, and less than 10% have never really played. Those who have little experience with video games are significantly less open to remote labor jobs (Fig. 5). With requirements on screen-mediated task execution, the indirect maneuver of tools, and complex eye-hand coordination, remotely controlling robots for labor jobs shares many similarities with videoendoscopic laparoscopy (either manual or robotic) in surgeries. Research has shown that experience with video games can significantly improve the skills of surgeons in videoendoscopic laparoscopy [Rosser et al. (2007), Grantcharov et al. (2003)]. It is reasonable to assume that experience with video games makes people more open to remote labor jobs and potentially do well in them.

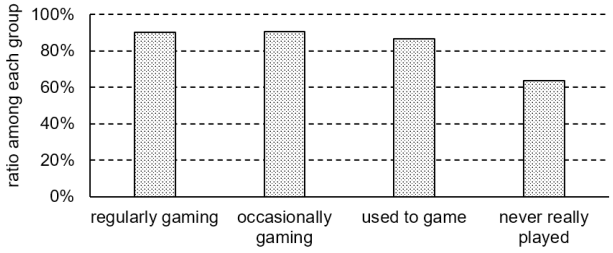

Fig. 5. Ratios of participants who would consider remote labor jobs among those who have certain levels of gaming experience

The questionnaire also asks the participants to specify the types of game controllers they use, including gamepad, joystick, steering wheel, VR headset, handheld controller (e.g., Wii Remote, PS Move, etc.), smartphone/tablet, and others. 57.3% of the participants have used three or more types of game controllers. 92.7% of those who have used gaming steering wheels definitely would or might consider remote labor jobs, while the ratio is lower at 85.3% among those who have never used such gaming gadgets. This echos the earlier finding on participants who have experience of driving vehicles in labor jobs are more open to remote labor. Designing the control interface of robot teleoperation to be more like video games could help the operators pick up the control skills easier. The strategy can be considered as a type of gamification, which refers to the selective incorporation of game elements into

a non-gaming interactive system to make it more effective [Deterding et al. (2011)]. In fact, manufacturers have already been adding game-like remote control interfaces to construction machines [Grayson (2014)], which bring them almost ready to be used for remote labor.

3.3 Employer Concerns

Figure 6 shows the participants' concerns when they picture working remote labor jobs. The top concern is about the required skills and technology. Robot teleoperation requires particular control skills, especially with the presence of feedback latency and the lack of haptic/force feedback [Chen et al. (2007)]. Systematic training is necessary [Tom et al. (2019), Grabowski et al. (2021), Adami et al. (2021)]. Meanwhile, due to the lack of long-term employee commitment, it is often difficult for employers of labor jobs to invest in employee training. New vocational education and training programs would be necessary if remote labor were to be practiced commercially. In terms of technology, remote labor requires reliable internet access with extra speed and steadiness, reliable power supply, and of course the control gadgets. It is reasonable for the employers to cover the technology cost on the operator side. A survey found that around half of employers of remote work subsidized home office equipment and service during the COVID-19 pandemic with Wi-Fi topped the list of expenses [Safety+Health Magazine (2021)]. The federal Fair Labor Standards Act of the US requires that employers may not ask employees to pay or reimburse their employer for work-related expenses if it would cause the employee's pay rate to fall below the minimum hourly wage, which much applies to labor jobs. In addition, many states in the US have state laws that require employers to reimburse employees for certain expenses while working remotely [Donelson (2021)].

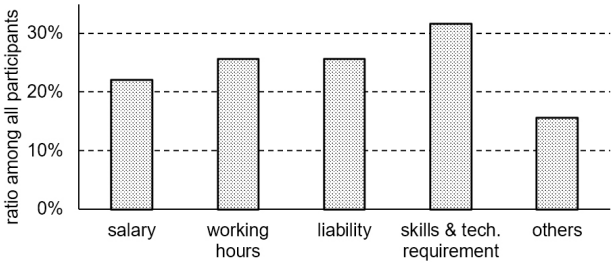

Fig. 6. Concerns about doing remote labor jobs

The second most identified concern is liability. Most research on robot safety focuses on autonomous robots. Nevertheless, safety technologies developed for autonomous robots could be used as assisting functions for teleoperated robots [Su et al. (2018)]. Meanwhile, liability insurance would certainly be necessary if remote labor were to be practiced commercially. [Bertolini et al. (2016)] gives a comprehensive review of the current insurance practices related to the use of robots, though the discussion related to teleoperated robots only includes the coverage of medical insurance in (locally teleoperated) robotic surgeries. Note that for most robots used today, the main operators - e.g., the robot technicians in a factory are usually considered the users. Meanwhile, for robots used in remote labor, the operators and the recipients of the robotic labor service (e.g., a patient who is being nursed by a remotely controlled robot) can often be different parties. It significantly changes the liability affiliation. For the manufacturers and operators of teleoperated robots, general product and operator liability applies, including the requirement of proper operator training and adequate safety protocols. A unique party involved in the safety and liability of remote labor is the internet provider. Damages could be caused by irregularities of network streaming bandwidth, transmission latency, video frame rates, and so on [Chen et al. (2007)] as well as cyberattacks [Bonaci et al. (2015)]. Overall, The technological complexity of remote labor makes it difficult to provide evidence and expert reports of incidents and identify liable parties.

In terms of the concern about working hours, thanks to the elimination of location constraints and commuting needs, remote labor could bring much flexibility to the conventional practice of work shifts in labor jobs. It is known that working remotely often induces extra and uncompensated working hours [Maurer (2020)]. Nevertheless, unlike office jobs, most labor jobs go by hourly wages and all working hours should be properly compensated. The concern about salary will be discussed later together with benefits. Some participants mentioned other concerns, most of which are about mental health while working from home (discussed in the next section) and the capability of the robots.

3.4 Home as the workplace

Rather than unanimously favoring working from home for remote labor jobs, a considerable 85.3% of the participants find it favorable or acceptable to work from an operating center near home (Fig. 7). Despite the explicit note in the questionnaire explaining that internet and equipment would be provided by employers, 11% of all participants answered "acceptable" or "no" to working from home while found it "favorable" working from an operating center near home. In fact, many find it distracting [Newport (2021)] and less motivated [Parker et al. (2020)] when working from home. Instead, an increasing number of remote workers prefer to work from a coworking place near home [Brady and Council (2020)]. The issues can be a lot more serious for remote labor jobs, which require a high level of constant attention to assure safety.

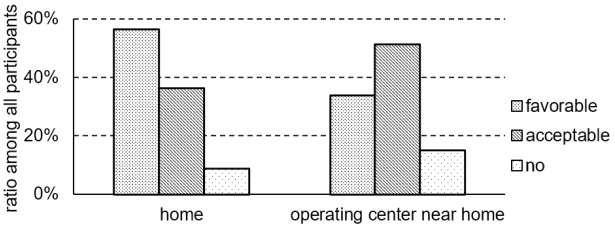

Fig. 7. Workplace preference for remote labor

Mental health is one of the most frequently discussed challenges regarding working from home. Many responses to the questionnaire mentioned issues related to mental health under "others" in Question 3 when asked about concerns about remote labor. Terms used in the answers include "disconnectedness", "desire of in-person interaction", "alienation", and so on. These issues have been well-known to cause mental impacts when working from

home [Toniolo-Barrios and Pitt (2021), Xiao et al. (2021)]. In addition, unlike most existing remote jobs, remote labor jobs require nontrivial hardware setup. Installation of a reliable power supply alone can be a major burden to the operators if they were to work from home. The additional utility expenses on power and water while working from home can also be a deal-breaker, especially for labor jobs with lower wages. With all the above factors, working from operating centers near home seems to be more practical for remote labor.

3.5 Salary and benefits

Question 5 of the survey first explains to the participants that the internet and equipment are additional costs to the employer, and asks if the participants would consider remote labor jobs if the salary or benefits were lower than their onsite peers. Despite that only a fraction selected "I do not mind as long as I can work from home", the majority of the participants found a lower salary reasonable and are willing to consider depending on how much it is lower. The opinion is not as open on benefits (Fig. 8). According to [Achim et al. (2019)], job seekers value benefits more than salary. 80% of participants of a survey by Glassdoor prefer additional benefits over a salary increase [Labitoria (2021)]. Meanwhile, remote labor actually would allow the employers to spend less on employee benefits without jeopardizing the coverage. In particular, remote labor eliminates the physical dangers in labor jobs and substantially reduces the cost of accident and disability insurance. The cost of medical insurance would be reduced as well because the occupational hazards caused by intense physical activities are avoided.

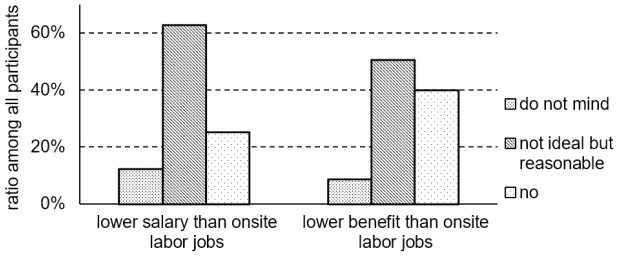

Fig. 8. Acceptance of remote labor jobs with lower salary or benefits

In terms of salary, remote labor jobs with a salary lower than their onsite peers do not necessarily mean a lower discretionary income, particularly because of the elimination of location constraints and commuting costs. A quickly increasing number of blue-collar workers in suburban areas are super-commuters who travel more than 90 minutes each way to work [Popov and Salviati (2019)]. Meanwhile, due to the demanding requirement of onsite presence, blue-collar workers in metropolitan areas are often forced to live closer to the work locations than white-collar workers and face expensive living costs [Balk (2021)]. Remote labor would allow blue-collar workers to live in affordable areas while eliminating the cost of commuting. In addition, research suggests that if time could be spent on working instead of in transit, individual income in the US could be boosted by over $5,000 a year on average [Marcellus (2021)]. Had the survey participants been briefed on such factors, they could have shown an even more open attitude.

3.6 Contracts and unionization

The location and time flexibility brought by remote labor could make it easy to hire operators as freelancers (as opposed to long-term employees). The practice could increase the labor availability on the job market but would also face labor rights issues and management challenges on safety and security. The majority of responses seem to hold an open attitude, though concerns about labor rights can be seen from the answers on unionization - when the participants are given the option to work as a freelance contractor instead of a regular employee, they would but are more likely to say no if they were not eligible for unionization as remote labor workers (Fig. 9).

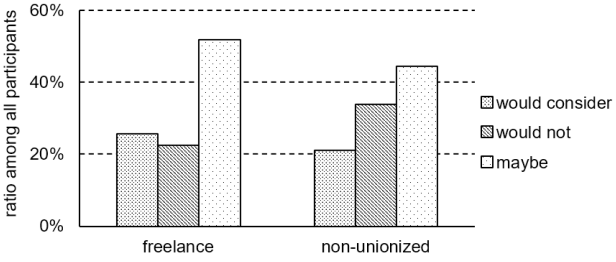

Fig. 9. Acceptance of freelance and non-unionized remote labor jobs

A novel business model based on remote labor is a robotized gig economy, where individuals who seek robotic labor services hire freelance remote operators directly through online platforms. Other than the gig platforms for ride-hailing (e.g., Uber and Lyft) and for online tasks (e.g., Amazon Mturk), platforms such Thumbtack, Fiverr, and Choremonkey have become popular for hiring freelancers for one-off jobs that require physical work. Leveraging such platforms, people can rent or own remotely controlled utility robots in their households and solicit freelance operators to control the robots and work on tasks ranging from babysitting and cleaning to construction and repair. As convenient as such a practice seems to be, safety and security (including privacy) would almost solely rely on the technologies of the robot manufacturers, which could be a huge challenge.

An alternative business model that can take advantage of remote labor's flexibility without jeopardizing labor rights and management effectiveness is to have dispatch services. Parties seeking robotic labor services (e.g., a construction site, a household, or a hospital) could solicit remote operators from a dispatch service. Employed by the dispatch service, the operators would be matched to tasks according to their skills, experience, and security profile. The equipment and internet on the operator side should probably be provided by the dispatch service, while the robots could be either owned by the service recipients or rented from the dispatch service. The dispatch service would be responsible for assuring labor rights of the operators and providing adequate management on safety, security, and so on. In fact, due to labor rights and management issues, ride-hailing services such as Uber and Lyft, which started as freelance platforms have been required by more and more authorities to treat and regulate drivers as employees and operate more like dispatch services [Zou (2017), Conger and Scheiber (2019)].

3.7 Data collection and use

As mentioned, a powerful function of remote labor is to serve as a data crowdsourcing platform for developing robot physical intelligence. Sensor and control data can be constantly collected from the operators while they remotely control the robots. With the widespread use of remote labor, crowdsourced machine learning can be practiced to produce and improve autonomous robot functions over the long term. [Zhao et al. (2020)] presents a robot learning scheme that can sustainably manage crowdsourced data and synthesize new physical skills that have never been demonstrated. When asked about additional opinions in Question 9, many are concerned about losing jobs to AI. Rather than taking away jobs, the increase of robot physical intelligence in remote labor could relieve the operators from the demanding real-time control of the robots, allowing each operator to simultaneously command multiple robots and scale up productivity. In addition to machine learning, data can also be used to evaluate the skills and performance of operators, investigate incidents, and train novice operators.

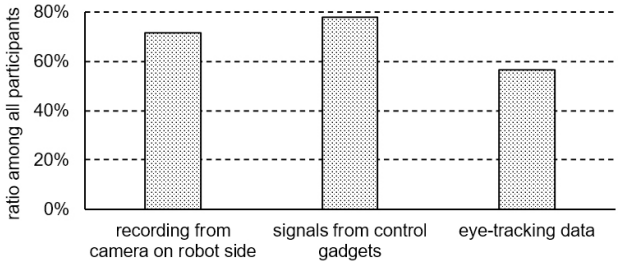

Fig. 10. Acceptance of data collection in remote labor jobs

The questionnaire lists three major types of data that can be used for the aforementioned purposes - signals from the control gadgets on the operator side, camera feedback from the robot side, and tracking of the operators' eye movement. Most participants are fine with collecting data from their control gadgets but are not as open to the other two types (Fig. 10). The lower acceptance of collecting data from cameras and eye-tracking is likely due to concerns about privacy, which is not surprising given the widely discussed controversy on the quickly increasing use of workplace surveillance [Zickuhr (2021)]. Though some participants might have not clearly understood that camera feedback from the robot side does not record the operator. Nevertheless, in applications such as remote driving, household service, and nursing, cameras on the robot side put the service recipients at privacy risks. [Holder et al. (2016)] examines data control in robotic services based on laws such as the Data Protection Acts in the UK, with detailed discussion on liable parties and recommended practices. Image augmentation technologies similar to body scans at airports [Dillon and Thomas (2015)] could be used to hide identification and preserve privacy in the video feedback from the robot side. Privacy-preserving eye-tracking can be done by detecting and filtering out privacy-sensitive situations [Steil et al. (2019)]. Technologies on privacy and security in non-robotic remote services could also be transferred and of use [Pramanik et al. (2019), Jiang et al. (2020)].

3.8 Overseas outsourcing

Remote labor would make it easy to outsource labor jobs overseas, where hiring operators could cost substantially less. Many would likely worry about losing jobs to foreign countries. As many shifted to remote work over the COVID-19 pandemic, there has been a heated public discussion on overseas outsourcing [Schnurman (2021)], as well as calls for regulatory measures such as the prospective End Outsourcing Act in the US [Minevich (2022)]. In addition, outsourcing labor jobs overseas using remote labor would bring challenges to performance and security. Lessons can be learned from the controversial overseas outsourcing of remote customer support services. The performance and security of foreign call centers have long been widely concerned in the US, though regulatory efforts have been fruitless [Michaud and Allen (2010)].

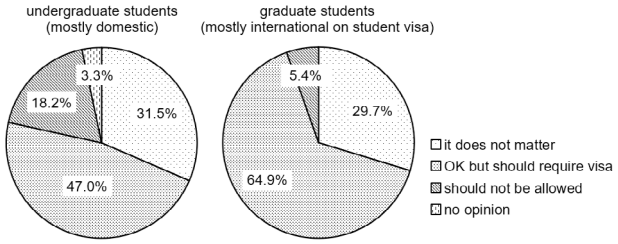

Fig. 11. Acceptance of outsourcing remote labor jobs overseas

The survey participants are asked to align their opinions to one of three options - "it does not matter", "OK but employment visa (with background check) should be required", and "it should not be allowed at all". As mentioned, the undergraduate students among the participants (83%) are mostly domestic while the graduate students are mostly international on the F-1 visa. According to their respective responses (Fig. 11), it appears that the international students are more open to allowing overseas outsourcing using remote labor, but also vote more for a visa requirement, possibly due to higher awareness of visa-related employment policies.

4. CONCLUSIONS AND FUTURE WORK

218 responses to a questionnaire have been collected to study the public acceptance of remote labor. In addition, the study has reviewed over 50 published articles on related technology and social challenges. A series of issues have been discussed, ranging from the influence of previous experience in labor jobs and video games, safety and liability, home as the workplace, data collection and use, overseas outsourcing, to salary, benefits, contracts, and unionization. Interesting findings include that people accept remote driving much more than other applications of remote labor; many are open to remote labor jobs with compensations lower than onsite labor jobs; working from operating centers near home could suit remote labor better than working from home; using gig platforms to hire freelance operators is impractical; and more.

Next, this study will leverage the findings from the initial responses and extend the survey to additional and more targeted groups. In particular, current full-time employees in certain types of labor jobs such as delivery drivers and

construction machine operators are of interest. The questions will be further developed to help the participants who have lower education levels better picture the technology. Responses from the employer side shall also be collected to study feasible and novel business models. The findings will help design practical robotic systems for remote labor.

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