Examining the Benefits and Social Implications of Sensors and Wearables in Construction

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Alexander T. Repak

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

Advisor

Richard Jacques, Department of Engineering and Society

Issues the Construction Industry Faces

Even though the construction industry makes up 7% of the world's working population (Barbosa et al, 2017), it has been neglected and left behind when it comes to productivity and safety compared to other industries (Ribeirinho, 2020). In fact, injury rates in construction are higher than the average of all industries by 71%, with 10 in every 100,000 workers dying each year (Current, 2021). People often think of construction, in terms of unsafe working conditions on roads or buildings and projects finishing later than scheduled, and for good reason, as the construction industry accounts for the most Occupational Safety and Health Administration standard violations (Construction, n.d). The increasing number of sustainability and site safety requirements will force construction companies and the overall industry to improve to remain competitive and of service to communities (Ribeirinho, 2020). The creation and integration of recent technologies in the past ten years has allowed many industries to improve their workflow and worker protection. In fact, some efforts to improve the construction industry include the use of technologies, such as productivity software, environmental monitors, and wearable devices. These new technologies can bring capabilities to construction and many social and ethical impacts, all of which will be discussed in this paper.

My technical project addresses a pressing subset of construction safety: environmental conditions on construction sites. The construction industry struggles with many forms of negative environmental impacts, which include air, water, soil, and noise pollution (Construction, n.d). This project consisted of working to identify and mitigate negative environmental impacts, in the form of air and noise quality, on the Contemplative Commons Construction Site at the University of Virginia. The team consisted of Katy Owens, Juan Chavez, Abid Hussain, Casey Calixto, and me.

The team first installed sensors to capture air and noise quality information around the construction site by working with Hourigan Construction in partnership. These air quality sensors are beneficial in detecting harsh conditions that could affect employees on site. Data analysis and interpretation allowed the team to identify strengths and weaknesses of the construction site environment. These findings were also given to Hourigan to allow them to adjust scheduling, staffing, and protective equipment selection. The gravity and importance of the work on my technical project and in this research, is shown by the fact that a person tragically died on the Contemplative Commons construction site due to a fall on March 14th, 2023 (Shuler, 2023). This unfortunate tragedy highlights the need for work to improve safety in construction and is a major motivator for my STS research.

While my technical project is important in improving construction safety, this paper will focus on my STS topic, which is related to another intriguing technology that is emerging in the construction industry: wearables. This paper will attempt to answer the research question of the safety, social, and ethical effect (positive and negative) of wearable devices on the construction industry. The discussion will begin by defining wearable technology and its reason for growth in the current day. The paper will also establish the benefits to consumer safety, wellness, and productivity that wearable devices bring to construction. Negative social effects and ethical concerns that come with the use of wearables technology in construction and the workplace will also be presented. Different forms of discrimination, health, and privacy legislation will be presented to show how they help minimize wearable risk and where they currently fail. The discussion will end with recommendations on if and how wearables should be used in construction and other workplaces, with steps to take to ensure ethical use now and in the future.

Methodology

To answer the STS research question of how wearable devices improve safety and affect the construction industry socially and ethically, scholarly research was chosen to gain a deeper understanding from experts of wearables, data, and construction. This type of approach qualitative information to compile the arguments and information from many diverse sources. More specifically, a subset of textual analysis called content analysis (Hassan, 2023) was used to answer the research question in this paper. The method entails collecting research from a variety of various sources, such as scholarly articles, journal entries, informative websites, and blog posts. Information from these secondary sources is adequate to complete the goal of defining wearable technology, gauging its possible positive effects on the construction industry, determining its possible negative effects on the construction industry, and providing a recommendation on how to quell these negative effects to implement wearable devices on construction sites while minimizing ethical problems. Google Scholar and the UVA Library Search Engine, Virgo, were essential to finding helpful secondary sources for this research paper. Keywords that were used within research include and are not limited to: 'wearables in construction,' 'wearable technology,' 'wearable technology legislation,' 'wearable technology in the workplace,' 'wearable technology privacy,' and 'wearable privacy issues. Resources found through these engines were rigorously examined to determine if they provided helpful and pertinent information.

What Are Wearables

Wearable technology, mentioned earlier in this paper, are autonomous devices that can be worn or attached to a human body to perform specific functions (Khakurel et al, 2016). Wearable technology began back in the 13th century with eyeglasses but has taken shape in the past 40 years with the creation and improvement of the computer. In addition, Bluetooth and better

processing power have brought us to our current selection of smart watches, and fitness devices (Franklin, 2019). The wearable technology industry, as of 2018, was worth $23 billion dollars (Brown A., 2021), and will continue to grow.

Within the construction industry, wearable devices bring technology and clothing together to help improve safety and productivity (Construction Industry, 2022). These types of devices can replace or be used in combination with any construction worker's clothing or equipment, such as boots, helmets, wrist watches, shirts, jackets, vests, or glasses. Two of the most prevalent features provided by wearable devices are GPS tracking and health monitoring (Waheed, 2019). With wearable technology being a part of the Internet of Things (IoT), it could transport data collected from the device to an external data source (Earnest et al, 2019). Normally, data from wearables is transmitted from the device to the manufacturer's cloud network, which the user or owner can then access through apps or dashboards on cell phones or computers. Below, types of wearables applicable to construction are broken down in more detail.

Types of Wearables

Sensor clips are small devices that are designed to take in data from the surroundings of a construction worker (Construction Industry, 2022). These devices can be attached to any part of a worker's clothing. Wearable sensors can have many different sensor types within them to take in many distinct types of data: a GPS to capture a wearer's location and an inertial measurement unit (IMU) to measure location and kinematic movement (Ahn et al, 2019). In addition, smart watches are devices that most people are familiar with in the form of Fitbit or an Apple Watch. These devices allow for communication (Construction Industry, 2022) and can track health information, such as cardiac activity through photoplethysmography (Ahn et al, 2019). Another wearable technology includes the smart cap, a wearable device for the head that takes in data on

the wearer's brain waves. These brain wave readings can be used to monitor fatigue and alert a worker or their employer when they are becoming too tired. Smart work boots are safety boots that have WIFI and Bluetooth capability. They can collect GPS data on an individual, use lighting to alert the wearer of danger, and report possible falls (Construction Industry, 2022). Exoskeletons are machines that provide skeletal support to wearers of the device. The device can be used as a full body suit or as a specific application to a body part, like an arm or leg. The purpose of the machine is to increase the strength capability of, in this case, construction workers (Forestell, 2020). The figure below provides a few examples of wearables in construction and how data from these sensors can be accessed. Layer 1 in the figure shows how these sensors can provide so much different information while being built into existing construction equipment. It also shows how the data can be accessed through a multitude of avenues in real time, like in Layer 2 or later, like in Layer 4.

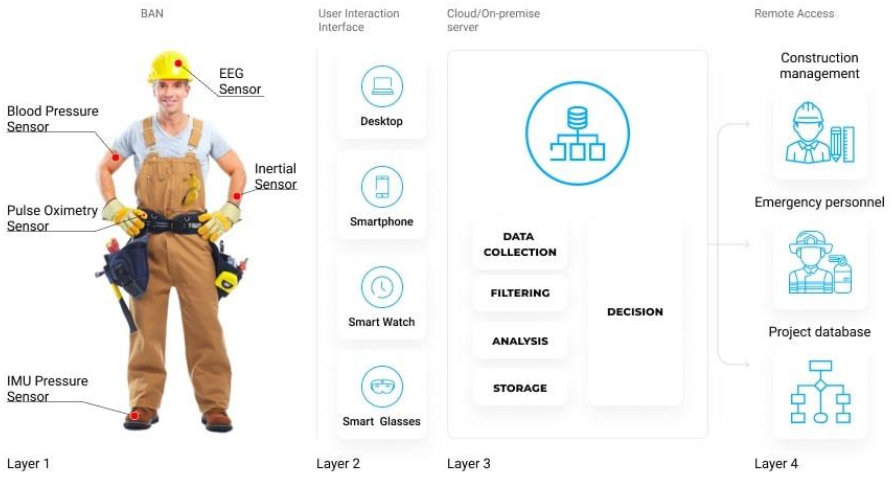

Figure 1: Example of wearables, how they are used, and their role (Makarevich, 2020)

Positive Safety and Social Effects of Wearables in the Workplace and Construction

While the previous section outlines many of the capabilities of wearable devices in construction, research shows how these capabilities can provide many safety benefits to construction workers on the job site. Employers can use these devices to track worker locations, whether it be specific body part movements or positions around a site (Khakurel et al, 2016). Knowing worker locations can be helpful in preventing accidents or falls, as falls represent 33% of construction accidents (Centers, 2019). Employers or the devices themselves can warn workers when they are in dangerous territory because of live equipment, extreme heights, or raw material. Employers can also have different health metrics at their disposal to ensure that employees are in good physical condition or have acceptable stress levels (Khakurel et al, 2016). Items like smart watches or smart caps can track the cardiac and brain health of each worker (Construction Industry, 2022), providing employers the opportunity to ensure that every worker is not overworked, overheated, or extremely tired on the job. Health information can allow workers to be taken off site or given a break if in poor physical condition, leading to many less human error accidents on construction sites.

There are also social benefits that are introduced with the use of wearables in construction and the workplace. Wearable technology introduced in the workplace can become positively involved in the personal life of employees. This entails workers voluntarily using wearable technology devices after working hours to improve their own lives. An example of this is using corporate wristbands or smartwatches that can allow construction companies to provide an effortless way to encourage healthy lifestyles in their employees through wellness programs. Wellness programs can bring lower health insurance costs for everyone involved (Maltseva, 2020). The morale of a construction company can also be positively impacted using wearable

technology. The ability for employers to have their employees' locations can allow them to make better informed decisions about worker allocation and work scheduling (Maltseva, 2020). These improved decisions can inherently improve work productivity, helping construction projects run quicker and smoothly and improving the lives of all stakeholders in a construction project (funding company, users, construction company). Figure 2 below is a visual representation of how the safety and social benefits from wearables discussed above can help improve employee engagement and organizational performance. It reinforces the fact that wearables can help employees focus on their work due to handling of safety concerns and that employees can have improved personal lives through wellness programs.

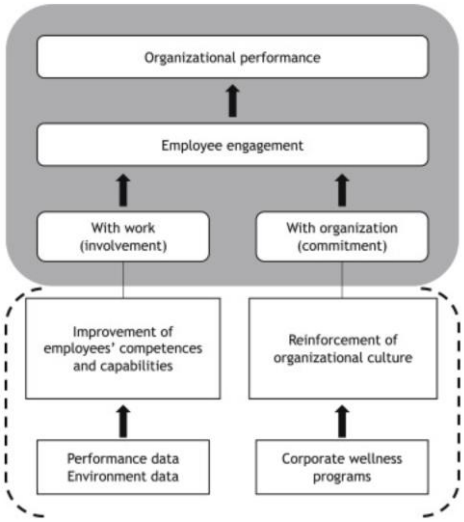

Figure 2: Framework for Benefits of Wearables in the Workplace (Maltseva, 2020)

Negative Effects of Wearables in the Workplace and Construction

One downside of the data revolution that has come with the increasing processing power of computers is the amount of user personal data that exists in tech company databases that could be exploited. On a worldwide scale, there have been many cases of large companies suffering data breaches that leave hundreds of millions of users at risk, including Yahoo in 2013 and 2014,

Facebook in 2019, and LinkedIn in 2021 (Hill, 2021). There are privacy concerns if wearable device data is accessed by outside sources, especially since some wearables take in health and fitness-oriented data (Kapoor et al, 2020). Having wearable devices that are connected to the internet opens the possibility that outside, malicious sources could capture location and heart rate information for specific workers. These malicious sources can take the form of out-of-company hackers (Gaff, 2015) or other fellow employees. Employers could be posing a risk to themselves and their workers if their employee wearable data is not safely secure with proper mechanisms, firewalls, and algorithms (Kapoor et al, 2020). Another way that wearable device data can be accessed by the wrong people is through the selling of data by the wearable device manufacturers, as the selling of data is very commonplace in large technology and social media companies today.

Looking at what user's thoughts on wearables are, research has been conducted in the past that can provide an insight. Many users of wearable devices have concerns with surveillance, lack of access control, location disclosure, and the right to forget (Motti, 2015). All these fears involve substantial amounts of collected data to be out of the user's control. Possible outcomes in many people's minds are using data to track locations, unauthorized people being able to see sensitive health information, or unknowingly collected data being used against them. These issues are holding wearables back from further adoption (Earnest et al, 2019), as 90% of construction workers have a smartphone, but only 9% use wearable devices (Ahn et al, 2019). Rules need to be established locally in companies and federally in the government that outline where data is going and what data is being collected.

In contrast to the risk of data being obtained by malicious or unauthorized sources, there is also ambiguity on how employers use the data that is collected from employer-issued

wearables. Ethically, there is a dilemma as to what extent employers can use collected data and how collected data can influence employer decisions. As mentioned earlier, many wearable devices can detect a person's health level or work performance. Collected health information could impact construction workers to an extremely high degree, as the construction industry has some of the highest rates of substance abuse of any industry in the United States. A study, from 2008 to 2012 showed that 14.3% of construction workers had a substance abuse disorder, second only to the mining industry (Bush & Lipari, 2015). Having collected health information from wearables could lead to some employees receiving help, but other scenarios could find employers firing employees due to detected alcohol effects near work time. While these discoveries could help work site safety overall, many people could lose their jobs due to data that is not previously collected. In addition, employers could make termination or layoff decisions based on heart rate and other data that could be correlated with disease (Brown E., 2020). For example, people with high resting heart rates could be more prone to lightheadedness and fatigue. Since health insurance is expensive, employers can try to use health information from wearables to favor people that require lower costing health plans (Brown E., 2020). Protections need to be in place to disallow companies from discriminating against employees based on collected health data.

A social problem that comes with wearable technology is the encroachment of work onto a worker's personal life (Maltseva, 2020). While this change was looked upon favorably in the form of wellness programs earlier in the paper, this merger can bring many problems for employees in construction. The required use of wearables in the workplace introduces possible negative psychological effects for employees. The objectification of employees as data sources is a gateway to employee resentment and stress, as many employees might view wearables as an

overstep on their rights (Maltseva, 2020). Wearables can blur the line between leisure time and work time, even during periods like an employee lunch break. In addition, wearables that track employee information after work hours, like in wellness programs, can be harmful to the perceived work-life balance of an employee. These psychological factors could decrease the morale, and henceforth, the performance of a construction company.

Workplace Legislation in Relation to Wearables

Protections for employees against data privacy concerns and data misuse stated above come in the form of legislation. Legislation about wearable devices when used in workplace settings, like construction, could provide clarity to employers, workers, and consumers about the acceptable use of employee and consumer data from wearables. Since wearables are very recent technologies, they either have not been addressed yet in legislation for workplace use (Haskins, 2017) or are tangentially affected by current disability and health legislation. There are large problems with wearables not having proper legislation in the workplace or them bumping up against current legislation, as wearables in construction and the workplace are not fully voluntary, like with regular consumer use. Legislation not yet being fully addressed or modified in relation to wearable technology in the workplace perpetuates the problems with wearables described above and the fear that many workers have about using them personally or at work. There are a few pieces of relevant legislation that could potentially apply to wearables.

The Americans with Disabilities Act (ADA) is an act that is designed to protect individuals with disabilities from discrimination and provide them with affordances. One part of the ADA states that employers are prohibited from administering medical examinations, with the only exception being out of business necessity in the form of a known medical condition for an individual that could affect a job (Haskins, 2017). Administering a medical examination includes

having enough data about an individual to discover a possible disability. Employers have health data from wearables about employee stress levels and cardiac performance could be in violation of this law. Employers might have health information that might reveal a disability, further violating the act. Wearable devices will have to be addressed to fit this legislation. Another good boundary in the ADA is that it restricts employee wellness programs to providing only aggregate data to employers and that a waiver of confidentiality cannot be required (Haskins, 2017).

Another law that is known for protecting the rights of individuals is the Health Insurance Portability and Accountability Act (HIPAA). HIPAA "establishes national standards for protecting individually identifiable health information" (Haskins, 2017). Although, there is no nationwide HIPAA protection or uniform data privacy policy for wearable devices (Marbury, 2020). In addition, HIPAA does not apply to employers, as it only applies to health plans and health care providers (Haskins, 2017). These facts currently leave employers unchecked when it comes to how they use employee data generally. While the ADA covers discrimination based on a disability, no HIPAA protection could mean that employers could sell data collected on the construction site to outside sources without problem. Since wearable devices and Wi-Fi connected devices are being used at workplaces much more, HIPAA needs to be evaluated to possibly include more protections for employees to avoid possible mishandling of sensitive data in the future.

Solutions Addressing the Potential Legal Issues

My first proposal to address these legal issues is to establish strict regulations within the ADA about what employers can gather from wearable devices. Employers should not be able to gather enough health data that can identify disabilities. My solution is to have reporting of wearable data be in the form of difference from the specific employee's average for health

metrics like glucose level and heart rate. While this idea would still use the specific data values from the collecting devices, employers would only be able to see if a person is better or worse than normal, eliminating the possibility that data is used to medically discriminate on a normal basis.

Another idea would be requiring the anonymization of health data gathered on construction sites, but that would largely eliminate the ability for employers to watch for employee safety from fatigue or dangerous falls on the construction site. My last proposal regarding legislation includes specific rhetoric in HIPAA about the responsibility of employers with their employees' data. With specific guidelines about the inability for employers to sell employee data and the anonymization or deletion of employee health data after a construction job ends, workers can become more receptive to using the new wearables. A higher level of clarity should also make many people more willing to use these devices in an informed capacity, leading to their adoption more quickly in the construction industry.

Research Takeaways

Despite immense technological innovation in the 21st century and the enormous size of the industry, the construction sector continues to be subpar in worker safety and productivity (Current, 2021). This paper has shown how wearable devices bring so many helpful safety measures that construction sites do not currently have in the form of fall and accident warnings through location tracking (Khakurel et al, 2016) and fatigue sensing through brain waves and heart rate data (Construction Industry, 2022). Many fatalities and injuries due to human error can be prevented on the construction site with these wearable devices. In addition, these wearable devices can encourage better physical health in off hours if desired for construction workers, addressing another one of construction's problems. Wearable Technology comes with many

ethical concerns though, especially in the form of data privacy. Data theft from malicious sources, discrimination, and employer misuse threaten the use of wearables in construction and the workplace.

My takeaway and recommendation because of my research and experience is to implement wearable technology within as many construction firms as soon as possible, if certain criteria are met. First, wearable implementation at this current moment would be at a voluntary level where workers could sign up to use the devices. Second, construction companies and other places of work are socially responsible for transparently detailing the specific data they will collect from employees and how that data will be stored. Third, updates to the ADA and HIPAA to include rhetoric about wearable technology needs to be investigated. If not updates to those acts, new legislation should be passed establishing similar restrictions on wearable technology. Full implementation can occur industry-wide realistically when legislation is put in place for wearable technology data privacy.

Future work in the area of examining societal benefits and ethical dilemmas of recent technologies in construction and the workplace could be taken in many ways. One area of future work is the further exploration and application of new laws about wearable technologies. A lawyer looking into the legal action steps of adding specific rhetoric to quell the ambiguity and concerns that wearables currently bring to acts like the ADA and HIPAA could be a beneficial step to take action on the ethical issues that have been presented to the table. Another direction that future work could take is how wearables open the door for robotics in the construction industry and what that means for possible unemployment or re-training of construction workers. Lastly, another future exploration could be the investigation into how wearable technologies can help low income or marginalized communities that lack health care.

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