Developing An Environmental Monitoring Dashboard to Identify Construction Activities That Affect On-Site Air Quality and Noise

(Technical Paper)

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

(STS Paper)

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Introduction

One industry that is ever present in the world around us, but always seems to be viewed as an annoyance, is the construction industry. The construction industry makes up 7% of the world's working population (Barbosa et al, 2017), but compared to other industries and the economies they operate in, it has been neglected and left behind when it comes to productivity and safety (Ribeirinho, 2020). 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. The following technical discussion will look to more specifically establish the safety and productivity problems that necessitate the existence of my technical project and explain how the project uses recent improvements in technology, such as monitors and wearables, to address those concerns. The following STS discussion will establish the benefits and privacy implications and concerns that come with the use of wearables technology in construction and the workplace as a whole and show the necessity for the formation of future legislation to ensure ethical use of wearable technology.

Technical Discussion

Although improvements have been made in recent years, the construction industry still has problems with safety, productivity, and environmental impact. There are many forms of negative environmental impacts that result from construction, which include air, water, soil, and noise pollution (Construction, n.d). In fact, the construction industry contributes to 23% of air pollution and 50% of climate change (How, 2017). These forms of pollution can lead to eye irritation, trouble breathing, hearing loss, heart disease, and many more for workers or surrounding pedestrians, especially for the elderly or people with preexisting conditions (Centers, 2019). Additionally, 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). Even with the use of personal protection equipment and stringent site regulations, safety problems persist. Not only do these environmental and safety problems affect workers on a construction site, but they affect bystanders that live and work near these sites since pollution can impact the quality of living in surrounding areas.

My technical work in the topic will consist of a capstone project, completed through the Department of Engineering Systems and Environment, which will entail providing support to the construction site for the Contemplative Studies Building at UVA operated by Hourigan Construction. My capstone team plans to help Hourigan minimize or avoid the issues of productivity and safety in two parts by using technologies that are already prevalent in other industries.

The first part of the project includes environmental monitoring on the construction site. Environmental monitoring can be conducted through the manual or automated collection and processing of feedback data on the construction site. For this project, monitoring and feedback

will involve placing air monitor sensors across the Contemplative Studies site within the construction zone and in the surrounding pedestrian-occupied areas to gather data about the pollution that the site generates. Central Grounds Garage and Ridley Hall are two areas with high pedestrian traffic that will be monitored. These sensors are small, four-inch by four-inch devices that are meant for indoor use, influencing their positioning around the construction site. The sensors will help the capstone team gauge dust particle matter levels and noise levels in high-traffic areas in and around the construction site. The data gathered from these sensors can be viewed on computer and mobile devices and will allow the team to identify the environmental impact that the construction activities have on workers, contractors, and surrounding pedestrians. The capturing of this air and noise data leads to the deliverable for this part of the project: an environmental health dashboard. This dashboard will be a software interface provided to Hourigan Construction that shows the environmental data in a summarized form to describe the environmental performance of their construction site. This deliverable will mitigate the technical project problem of negative environmental and health impacts resulting from construction by helping to identify which activities produce the most noise or air pollution, allowing Hourigan to adjust better serve their workers and the community.

Figure 1: AWAIR Omni Air and Noise Quality Monitor to be used on the Contemplative Commons Construction Site

The second part of the project includes gathering information about data collection on the Hourigan construction site. To get this data, interviews will be conducted with Hourigan employees, contractors, and subcontractors. These interviews will consist of questions that will gauge the existing safety practices on the construction site, workers' opinions on surveillance, and workers' willingness to provide productivity and health data to their employer. This data will be analyzed and presented to Hourigan to display the sentiment of monitoring by their employees and associates. This information will help Hourigan decide whether surveillance and wearable devices can be employed and used for the next capstone team, in addition to gauging sentiment on data tracking at a user level. The interviews are meant to be a pathway to getting smart watches on site for another capstone team to further help Hourigan.

Figure 2: Inside View of the Contemplative Commons Construction Site

STS Discussion

Wearable technology, mentioned briefly earlier in this prospectus, 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, 2021), and will continue to grow.

Since modern-day wearable devices can be classified as miniature computers, they can have many distinct functions. Two of the most prevalent features provided by wearable devices are GPS tracking and health monitoring (Waheed, 2019). In fact, wearables like the Fitbit and heart sensors are already being used in the fitness and healthcare industries by consumers. In the workplace, wearable devices can really help employers make the well-being of employees and process management of the business a priority. Employers can 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). 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). This feature is very applicable to construction, as being able to see where each worker is located and how long they spend in certain positions can help with productivity improvements.

The 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 are health and fitness oriented (Kapoor et al, 2020). Employers could be posing a risk to themselves and their workers if their employee wearable data is not secure. In fact, research has been conducted in the past to examine user's thoughts on wearables. Many concerning topics have been uncovered, including surveillance, lack of access control, location disclosure, and the right to forget (Motti, 2015).

In contrast to the risk of data being obtained by malicious sources, there is also ambiguity on how employers use the data that is collected from employer-issued wearables. There is an ethical question as to what extent employers can use collected data. A question that deserves further investigation in my STS project includes: Can employers use wearables to determine job status? Many wearable devices can detect if a person is in bad physical health or see the level of productivity that an employee is having. Especially for an industry like construction, where physical ability is necessary, should the data that these wearables provide be used to assess the performance of employees in their role? This question is relevant, as there is no nationwide

HIPAA protection or uniform data privacy policy for wearable devices (Marbury, 2020). In fact, this question leads into my STS project of examining the proper use of wearables in a workplace setting to maximize their benefits, while also accounting for the data privacy concerns outlined above. This STS topic is loosely coupled with the technical topic, as it takes on one of the technologies that will be briefly addressed and used in my technical project and explores the specific benefits and concerns that it brings with use in the workplace.

Research Question and Method

My STS research will attempt to answer how the emergence and use of wearable technologies, such as exoskeletons, smart watches, and GPS enabled wearables, by employers will impact construction workers and workers of other industries. More specifically, I will try to provide usage recommendations for smaller companies, such as Hourigan Construction, on how wearables should be implemented and how data should be used. My research will consist of two parts that will come together to give a final recommendation on the use of wearables in the workplace. The first branch of research will include the new abilities that wearable devices provide to companies to gauge the benefits that they provide to employers and employees. The second branch of research will include an investigation into the existing uses of wearables in any working industry to see how privacy and worker data protection are currently being managed. Data privacy concerns with wearables, such as the extent of data use and the sharing of data, will be investigated to gauge the risk that these devices pose to workers. These two avenues of research will be used to provide advice and next steps on proper use and legislation of wearable devices in a workplace setting.

Conclusion

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). In addition, the construction industry is responsible for a substantial portion of dust particle and carbon dioxide emissions that have repercussions for communities and the environment (The Environmental, 2017). These problems are the motivation for my technical project, which will identify and analyze environmental quality and worker feedback on the Hourigan Construction site at UVA. The technical project will deliver an environmental quality dashboard to Hourigan for identifying the impact their site is making and data on Hourigan construction workers' thoughts on current safety practices and privacy concerns. Wearables, one of the technologies that has begun to enter the construction industry to address these problems, has its own benefits and data privacy concerns. These privacy concerns will be explored in the STS portion of the project to provide recommendations on wearable use and regulations for Hourigan and legislations for overall workplace use.

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