Investigating Novel Proximity Monitoring Techniques Using Ubiquitous Sensor Technology

Addressing the Psychological and Social Dimensions of Wearable Technologies in Sports

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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

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Introduction

The spread of the novel coronavirus resulted in the immediate stoppage of sports leagues across the world. Gradually, these leagues have begun to reopen, with player safety paramount. Many regulatory procedures have been enacted, including mandated wearable sensors to ensure proper social distancing of six feet to prevent the spread of the disease. As these sensors have been implemented globally, questions about measurement accuracy, social impact, and physical comfort have arisen.

My research will address these questions at a social and technical level. On the technical front, I will compare the accuracy and reliability of different wearable proximity solutions. I will then analyze the proximity data to produce actionable insights for sports' organizations. Socially, I will address this technology by learning its impact on player's psychology, team dynamics, and physical comfort. This will help evaluate the potential side effects of the device's implementation across the world.

The synthesis of these two aspects of wearable sensor technology in sports will provide a holistic analysis on the topic. Recommendations on how to properly implement these devices in sports will be backed with a multidimensional approach and should be used by organizations globally.

Technical Topic

UVa athletes currently don't have a technology that can monitor the distance between them and other players. COVID-19 has challenged sports teams to come up with feasible and easy-to-implement solutions to provide a safe training environment for their players and staff.

The purpose of this project is to leverage sensor technology to improve performance analytics and to determine how to measure the distance between athletes in real time. We will be working with researchers from the department of kinesiology and UVA Department of Athletics to test novel sensing methods to see how they can be incorporated in current practices and to the extent the results can be trusted.

Currently, we are looking at motion, Bluetooth, and sound data collected from Huawei Watch 2s worn by the UVA men's basketball team. We will focus on Bluetooth and ultrasound sensor metrics in our technical analysis to analyze distance measurements and compare accuracies based on controlled experiments. Our team is in the midst of acquiring new SafeSpacer technology, however. This is an ultra-wideband (UWB) wearable social distancing solution. If it is successfully procured, it will also be compared to the other protocols. We are also limited by the inability to observe basketball practices in person. The scope of this project will focus on distance measurement strategies, usability, and potential solutions.

Figure 1: Huawei Watch 2

Our plan is to investigate ubiquitous sensor technology that can accurately measure the distance between athletes while they are wearing a device. We will conduct a controlled experiment in which we will set sensors at set distances and then will analyze the resulting. Eventually, we will use the associated app to download data to the cloud and we will attempt to create network between the different wearable devices that calculates distance accurately.

This is a year-long project in which the first semester will be dedicated to exploring various methods of data collection, conducting sensor research, running controlled experiments, and analyzing collected data. The second semester will be focused on compiling our findings and using them to create our final deliverables. These will most likely be some variation of software or suite of algorithms to assist in the collection of real-time distancing data and the comparison of different sensor technologies. We will also work on writing a technical report in which we discuss our work.

STS Prospectus Introduction

Wearable technology, specifically proximity sensors and motion trackers, have long been introduced in sports and have many useful applications. For example, this data has been used to analyze load management for athletes, meaning ensuring they are not being overworked in practices and games as outlined by (Bucheit, 2017). With this analysis, decision-makers are more informed on injury risk, how to improve efficiency in practices, as well as more insightful individual-based training programs.

One example of the technology's current success was deliberated by (Baccellieri, 2020). This article highlighted a successful Covid-19 prediction in the PGA. The day before a high-exposure golf tournament, Nick Watney's Whoop smartwatch notified him of a spike in respiratory rate, inciting him to take one more Covid-19 test, despite consistent negative results. This test returned positive. Watney was then able to quarantine successfully without endangering the families and lives of his competitors. This clearly demonstrated the potential medical success of the technology, and proves the need to encourage increased distribution.

The Covid-19 pandemic, however, creates another application of this technology as well: ensuring social distancing. The technology can calculate distance between itself and another device, meaning it can be used to ensure 6 feet distance between players, coaches, and staff. Professional sports leagues across the world have started to implement this solution.

This STS research will start by analyzing the implementation of different social distancing solutions across sports. This will look into why different sports are implementing different technologies, all stakeholders involved, how effective it has been, and how users have reacted to the change. Then, I plan to analyze the social aspects of this implementation with a local case study: the UVA soccer team. This research will dive into how the wearable impacts players' psychology, team dynamics, practice routine, among other factors through interviews with the team and staff. This analysis will help us understand some of the broader implications of implementing the technology and how it impacts the players.

These problems could greatly benefit from STS investigation and wicked problem framing due to the massive scale of the issue. Sports are played daily around the world and all leagues, recreational, collegiate, and professional included, could benefit from the insights

created from this analysis. In a similar sense, it is important to consider how many stakeholders are involved. Players and staff are concerned about their safety as well as team performance. League and team owners want their respective leagues to restart safely in order to generate revenue. Fans watching these games do not want athletes to be given special treatment, while regular people are strictly adhering to government regulations. There are many angles to consider with this problem, making it intriguing for STS investigation.

Research Questions

1.) Through what mechanisms do different sports leagues implement different technological social distancing solutions and why?

2.) How have the social dimensions of team meetings, practices, and games changed with the addition of wearable technology? (player psychology, team dynamics, etc.)

3.) How do wearable devices affect injury risks and other physical dimensions of sports?

Research Question 1 will be explored through a literature review of current sports league's Covid-19 protocols, utilizing the NBA bubble as the primary example. Using an empirical case study including the UVa Basketball team, Research Questions 2 and 3 will be addressed thoroughly.

Literature Review:

Studies analyzed the potential impact of wearable technologies for infectious disease before the emergence of Covid-19. (Radin, 2020) discuss the analysis of Fitbit data from 2016 to 2018 in order to predict influenza-like-illness in the USA. The study determined that the addition

of the Fitbit data significantly improved the prediction models, identifying the potential to enact timely response protocols due to the data. (Seshadri, 2020) emphasizes a "call to action to harness our digital infrastructure" in order to combat the spread of the virus. The journal analyzes cardiovascular, respiratory, temperature, and other physiological data points in order to accurately predict the presence of the virus without significant symptoms. Similar implications were discussed in the journal written by (Hagen, 2020). This journal interpreted West Virginia University's usage of sleep tracking, heart rate variability, and performance data.

Another use case of wearable technology was studied by (Pepin, 2020). This journal explained the analysis of wearable technology data in order to determine the population's compliance to home confinement policies. The results showed that lockdown policies did significantly lower a population's movement, however not for partial lockdowns, proving the value of this analysis.

The primary concern of athletes regarding wearable technology is the privacy of their data. This has consistently been expressed by players, such as Kyle Kuzma in the NBA. (Baccellieri, 2020) quoted Kuzma saying the Oura Ring "looked like a tracking device". This will always be a consideration as technology becomes more engrained in our everyday lives, but is important to mitigate. The NBA claims the data is anonymized; however, player suspicion will remain. Security concerns are reasonable, as described by Ching and Singh. This journal analyzed security issues in Fitbits, smartwatches, and Google Glass. Fitbit devices could be hacked to attain location, user information, and personal health data. Similarly, Google Glass was at exposure to Wi-Fi hijacking. These concerns need to consistently be addressed in order to safely transition to the implementation of these devices. An alternative perspective was provided by (Thierer, 2015) in his journal article. His argument was that while security issues need to be

addressed, strict regulations to adopt the technology will only hinder its potential and beneficial uses. This argument is important to consider as we weigh the tradeoffs between saving lives and global data security.

Another important factor to consider is the accuracy of the data being generated, and to what extent critical decisions can be made given its error. It would be hard to recommend the technology without assurance of the highest accuracy of motion and symptom tracking. This concept was scrutinized by (Pobiruchin, 2020) in her journal. After analyzing a variety of devices, it was determined mobile phones slightly overestimated the distance of a half-marathon, with a mean absolute error of 0.35 km. GPS-enabled sports watches yielded a better error rate. It is important, however, to consider these results in a Covid-19 context. If the metric of interest is social distancing, it is crucial these distance measurements are accurate. While devices are becoming more accurate, it will be very important to consistently improve the margin of error. (Navalta, 2020) looked into similar validity experiments with wearable technology. His results yielded that different commercial technologies resulted in different heart rate accuracies, with the chest-located device having the highest accuracy. We must consider the tradeoff between accuracy and comfort, and my research intends to dive into this question while interviewing athletes about different sensors' impacts.

There exist other implications of wearable technology in sports. One of the most important is how the data can be used against players, in particular with regards to contracts. (Berman, 2020) looks into this dilemma. Who has ownership of the data? Player unions address the concerns of these players and have ensured the data cannot be used in contract negotiation. The role of these unions will be crucial in order to protect the players' interests while implementing the life-saving technology. (Balletta, 2019) similarly analyzes the role of player

unions in the MLB with regards to wearables. Players want to ensure their privacy and be confident their organization is not tracking their sleep, movement, and diet. Given the MLB's rich antitrust history, the players distrust of the organization seems quite reasonable. The negotiation process between sports leagues and players will be detrimental in determining the impact of this technology at a global scale.

From the above, we can see there has been a significant amount of research into the implications of wearables in sports due to the Covid-19 pandemic. There exist, however, large gaps in this literature that fail to discuss the social dimensions of this technology. How does the technology affect team performance? How does it affect player psychology? These aspects I intend to explore in my research with the UVa soccer team.

STS Frameworks

To address the first research question, I will apply the Winner's concept of politics with technology. This is important because of the inevitable politics before any sensor policy is mandated across a league. I will apply this framework to the case study of the NBA Bubble, one of the first and most successful returns of a sports league.

In the world of sports, the organizing league, in this case the National Basketball Association, holds the power in deciding how to safely operate. The NBA, led by commissioner Adam Silver, created one of the more novel solutions with the bubble, requiring a 10-day quarantine upon entering, constant Covid tests, and social distancing sensors. Furthermore, an estimated $170 million was spent by the NBA on the bubble, meaning just as much must be generated in the form of revenue to turn a profit. To counter these conflicts of interest, players

have a labor union named the National Basketball Players Association to represent their ideas and protect the safety of themselves and their families.

The technology is only recommended for players, but mandatory for all non-players. The stricter regulations for non-players are intended to support the athletes' ability to safely interact while violating the standard social distancing procedures the public follows. The technology certainly reconfigures social relationships within the bubble. Members are sacrificing normal life to be there, yet are constrained to move freely by the sensor despite constant negative Covid tests. Furthermore, it gives the NBA access to so much proximity data, giving them significant power over all the people located in their bubble.

This technology has the potential to create an impact across the world. For one, the NBA is one of the most watched events each year, providing mass exposure for the sensors. More importantly, however, the NBA bubble is working. There have been 0 positive cases and only one breach outside the facilities. This provides the sensors with a huge opportunity to be utilized in different, more widespread settings. Applications in the work-place, hospitals, and other critical locations seem all too logical with the bubble's success and the power of data. The sensors are the start of a long line of innovation to help maintain social distancing in these unprecedented times.

Another STS framework I will apply to further analyze this question is actant-network theory. This is because of the multitude of human and non-human actors that are crucial to the spread of the technology. This analysis counteracts Winner's political analysis by reconceptualizing the role of objects and their action in society. It argues that the construction of technology is through both humans and non-humans, not only by politics or social groups.

Some of the human actors recruited into the network are the athletes themselves, league executives, governments, researchers, and player unions. The most important nonhuman actants to consider are the wearable devices, the media, and policy. Athletes use the technology, and spread awareness of it to the masses through the media. League executives decide policy regarding the technology, and ensuring this aligns with government mandates as well. Player Unions protect the interests and safety of the players before any policies are finalized. Finally, it is very important to consider the scientists and tech firms who are constantly unlocking novel applications of wearable technology in sports.

There have been many instances of successful and failed processes of translation in the formation of this actant network. One strong example to consider is that between the athletes, the technology, and league executives. Athletes have consistently expressed their concern the wearable device looks like a tracking device and are concerned about data privacy and anonymity. The providers ensure the data is completely anonymous, however. League executives weighed in by emphasizing the importance of player safety and desire to resume playing their respective sports. This process of translation was crucial in redefining actants' interests, addressing concerns, and creating policy that all parties will agree to and will be mandated to follow. Another translation occurring in the system is between the athletes and the media. Professional athletes have media "followers" on the order of millions, and have been actively promoting safe practices while playing sports and the benefits of the technology. Through this medium, the technology has spread to more and more sports leagues across the world, including the NBA, NFL, English Premier League, Bundesliga, and more.

Methods for Data Collection

For my first research question, I intend to conduct a thorough document analysis regarding different leagues' protocols in returning to their sports during Covid-19. This will focus predominantly on the NBA Bubble due to its success and timing, but will also take into account other popular global sports leagues. This will give us a thorough understanding of the different mechanisms that occur in order to allow for the return of the respective league in a potentially unsafe environment. With regards to the second and third research questions, I intend to conduct interviews with players on the UVA soccer team as well as other staff and coaching personnel. These interviews will try to get a more qualitative perspective on wearable technology, players' concerns, how it impacts their gameplay, their psychology, and other factors. An interview is the best way to pursue this research because it is more in-depth in nature than a survey while still understanding the qualitative aspects of the player-technology relationship. True understanding of this relationship cannot be described by participant observation, only by the players themselves. The people I plan to interview come from a small sample, so it will be practical to be thorough with each interview in order to get a very detailed perspective from the athletes and staff interviewed. This data will then be synthesized and analyzed in order to understand how players interact with the technology and to what extent it impacts them.

One identified source of bias is due to the small sample size. Given I am only interviewing the UVa soccer team, it will be hard to scale these findings globally. Furthermore, relationships with technology will differ across different world cultures, as the rate of technological implementation adapts globally. To mitigate these, however, we will combine the interviews with a thorough document analysis on related topics. Understanding players'

relationships with the technology in other sports and globally will be crucial in order to understand the true nature of the situation. Furthermore, it will be important to validate my findings with the UVA soccer team across a diverse set of situations.

Timeline

The research plan, milestones, and timeline are established as below.

Milestone 1: Complete Document Analysis by February 20, 2021

Milestone 2: Conduct Interviews of UVa Soccer Team by March, 2021

Milestone 3: Analyze findings of UVa Soccer Team by April, 2021

Milestone 4: Finish Thesis by May, 2021

Conclusion

The social dimensions of wearable technology in sports have not been addressed thoroughly enough. My research intends to explore these gaps, specifically why different solutions are used in different sports and how the devices impact the players psychologically, physically, and as a team. Through this, more robust recommendations will be able to be made to safely return sports, while mitigating external side effects of wearable technology. Interviews with UVa soccer players and staff will be synthesized with a thorough document review in order to provide a comprehensive analysis.

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