

Guidelines to Responsible Virtual Reality Development

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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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ABSTRACT

Virtual reality (VR) technology has enormous potential to change the world for the better; however, significant ethical issues unique to VR exist that must be addressed to ensure that VR technology only benefits users and does not harm them. In service of this goal, I propose modifications to typical computer science software development practices, thus providing guidance to counteract potential ethical conflicts and sources of user harm. I adapt these modifications into the AGILE industry-standard software development lifecycle, providing a framework for not only what ethical issues should be addressed, but at what stage in development planning should occur to counteract those concerns. This will minimize additional cost and time constraints, a chief concern for often cash-strapped VR developers. As a result of implementing these modifications, VR developers will be able to ensure that their VR experiences counteract the most pressing ethical issues facing VR today. In addition, they will be able to do so in the least costly method possible by reducing the number of changes in operating procedure. While AGILE is the most common development method, it is not the only one used in the CS industry. Future work is needed to generalize this research across a multitude of software development lifecycles.

1. INTRODUCTION

The VR industry is one of the fastest growing technology industries today, with unparalleled potential to up-end established practices in various industries (Petrov, 2023). However, the technology is so new that the speed of the industry's growth is vastly outpacing researchers' ability to predict or

assess the potential negative impacts that VR technology might have (Slater, et al., 2020).

Already, several VR applications have been known to harm their users, with effects ranging from loss of data privacy, motion sickness, and even some VR applications serving as a tool for sexual predators. VR so far has yet to reach most consumers (Grand View Research, 2022), but the industry is fast accelerating its growth. Guidance is needed for VR developers to make sure that their applications keep their users safe, which this paper aims to provide.

2. BACKGROUND

The true conception of the modern VR industry came with the release of the Oculus Rift in 2016, widely considered to be the first consumer-ready headset. VR enthusiasts with sufficiently powerful computers needed a large room, had to set up multiple external cameras, and had to have a wire plugged into a PC extending from the headset, resulting in a clunky and difficult experience.

A mere seven years later and accelerated by the COVID-19 pandemic, the technology available for users to immerse themselves in VR has expanded beyond the wildest dreams of even the most optimistic consumers. Modern headsets are powerful enough to operate free of a PC, allowing incredible portability for VR technology. Haptic vests allow users to physically experience the sensations that occur to their characters within VR. VR "treadmills" allow users to have their physical movements translated into VR experiences, and devices even exist that can allow users to smell the locations they visit in VR. Industries from many sectors are looking to implement VR technology to revolutionize their operations, with VR mental

health treatments and VR job training being some of the most prolific examples. Tech giants like Meta, Google and Apple are racing to one-up each other and emerge as VR industry leaders, and for good reason. With a global valuation of \$28bn in 2022 and a projected revenue of \$87bn industry-wide by 2030, the profit potential is enormous (Grand View Research, 2022).

Such explosive growth in the VR industry and associated market competitiveness naturally means that companies are striving to rush VR experiences to consumers as quickly as possible. As such, it stands to reason that expediting the software development process from concept to delivery is often given more importance than thoughtful development with respect to ethical issues.

3. RELATED WORKS

VR as an industry has been on a small-enough scale that research into potential ethics violations and negligent software development is limited. However, despite VR technology's novelty, there have already been examples of VR companies failing to adequately safeguard their users. Existing research on ethics in VR seems dedicated to identifying issues rather than offering solutions.

3.1. Data Privacy

In 2018, the VR experience "Bigscreen" was found to be streaming users' computer desktops without users' knowledge or consent, without blurring out sensitive information like passwords and financial data. It also allowed malicious actors to spread computer viruses to any user who entered the virtual room, constituting severe failures to protect users' data privacy (Priyanka, 2020).

3.2. Mental/Physical Health

Many VR experiences have construed themselves as mental health and wellness applications, but standards are lax on their quality. In a study on free VR applications available to consumers, researchers found that a mere 22% of 50 applications identified as possible tools for therapeutic purposes and meeting study criteria were judged to have *any* mental care potential upon trial (Bell, 2021). Additionally, motion sickness is a recurring issue for VR consumers worldwide,

frequently taking a great toll on many VR users (Steinhausser, et al., 2022)

3.3. Predatory User Behavior

One of the most concerning examples of companies failing to protect users is in the case of "VRChat," an extremely popular VR social platform with tens of thousands of users online at any given time. To get a sense of what children were being exposed to, given the application considered itself acceptable for users of age 13 and up, BBC researchers investigated the platform (Crawford, 2022). They found rampant predatory behavior from other users, with the researcher being exposed to rape threats, racist insults, and users playacting at having sex in an immersive virtual environment. Additionally, there have been multiple cases of law enforcement officials arresting individuals for predatory sexual behavior towards children on this platform.

3.4. Attempts to Address

VR companies have attempted to combat problems that arise on their individual VR experiences, with mixed success. For example, "Bigscreen" successfully patched their data privacy leak before known malicious actors could take advantage of it, using the assistance of a research team (Priyanka, 2020). VRChat has implemented a "user trust" system which gives users additional permissions based on good behavior, and manual moderation teams use metadata to identify and remove users who violate their terms of service (VRChat, 2018). However, given that these systems have been in place for years and the BBC report on predatory behavior is only a year old, it is evident that these systems are failing to properly safeguard users.

3.5. State of the Industry

Despite many of these VR applications being owned by large tech companies with experienced in software development, it is evident that skill in developing applications for a two-dimensional computer screen does not translate perfectly into VR development. When considering this in the context of the VR industry's rapid growth, the obvious conclusion is that the impact of failing to

adequately protect users is only set to increase. Some of the most pressing ethical concerns facing the VR industry relate to data privacy, addiction, physical and mental health concerns, and struggles with moderating user behavior. While each of these problems have manifested themselves in some form or another in the field of computer science at large, the radical differences between using VR and using standard computers mean that these ethical challenges have taken on new and unexpected forms.

3.6. Absence of Guidance

Individual VR development teams are aware of issues affecting their own platforms and are trying to take steps to resolve them. However, in extensive research, there seems to be no publicly available concerted attempt to coalesce the most pressing VR ethical issues into a developer-focused framework for addressing them.

4. PROPOSED DESIGN

To provide context for my proposal for an ideal ethics-focused VR development lifecycle, I will begin by describing the primary ethical concerns that new VR applications must address, as well as explaining the core tenets of AGILE development.

4.1 Goals of Development

To ensure they are developing new VR applications in an ethical manner, VR development studios should make sure their applications are constructed with the following ethical concerns in mind:

1. VR applications must not collect, transmit, or allow other users to access information about others beyond what is necessary to run the application and keep users safe.
2. VR applications that expose users to other users must have some means of enforcing acceptable behavior, especially when vulnerable populations are using it, such as children.
3. VR applications that purport to offer some kind of tangible benefit (job training, mental or physical health) must have some professional oversight beyond development teams themselves.

4. VR applications should ensure that their monetization practices are fair and equitable, and do not prey on those who struggle with addiction.
5. VR applications should care for users' health and reduce the likelihood of making users feel sick or inflicting distress on them.

4.2 AGILE METHOD

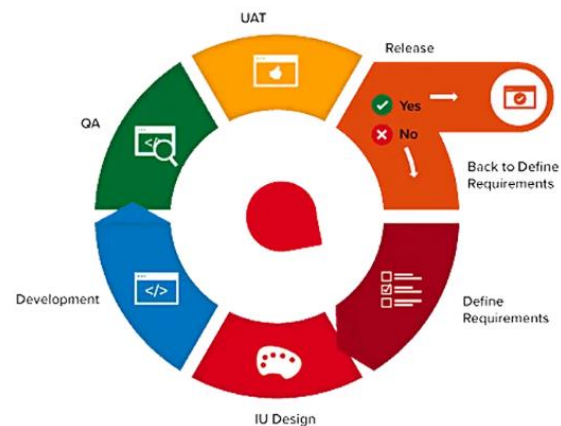


Figure 1: AGILE Development Lifecycle

The AGILE method of software development provides a basic framework for software developers to develop applications with a focus on collaboration and enhancing the eventual users' oversight and influence on the development process. The AGILE method is broken down into several stages. It begins with defining requirements for the software; producing design concepts for how the product should look in its end state; proceeding with actual development; quality assurance testing; receiving feedback from users; and proceeding to the software release or repeating the cycle based on the feedback. This method of development is the most widely used among software development teams and it is prudent to apply VR development lifecycle modifications to it for maximum effect.

4.3 Agile Development for VR

To integrate ethical standards in VR development into VR developers' established work practices, I propose the following modifications to the AGILE development lifecycle.

4.3.1 Defining Requirements

This stage of the AGILE development lifecycle is the most crucial stage for addressing ethics questions related to monetization and addiction. How an experience is going to be profitable, if it is designed to be so, must be determined here. Game studios, for example, often engage in using “microtransactions,” or purchases that are made within an application. These are reputable for their immense profitability at the expense of increasing rates of addiction among users (Parasuraman, 2017). With the increased immersion of VR, it is easy to see how predatory monetization tactics could make addiction prevalent—development studios must take care to design their business models to protect users.

4.3.2 Designing Concepts

This is the stage at which the issue of caring for users’ physical health comes into play. Many VR applications do not offer the ability for users to modify the intensity of the experiences, and the unique challenge of VR is that users cannot truly get a picture of what it feels like to experience something themselves by, for example, viewing videos of others using the application on a 2D computer screen. To properly ensure the safety of users, studios must prepare at this stage for the implementation of a trial version, or some means of reducing the intensity of the VR application, allowing users to customize their experience.

Furthermore, the high computing power requirements of VR applications can cause lower-end computers to struggle to render the VR applications within a VR headset, inducing serious motion sickness on users. When designing the concepts for what a VR application will look like, development studios should ensure that the projected hardware requirements are minimized for the application at this stage, thereby reducing the likelihood of causing motion sickness. This can be done in practice by reducing the visual complexity of assets.

4.3.3 Development

At this stage, data privacy protections must be implemented and heavily tested. Data must be made secure by operating under the principle that data should be made private by default, and only

publicized if the application requires it to run. Attempts need to be made by the development teams to break into their own applications and use small-scale, incremental testing to make sure that faulty data protection does not pass this stage.

Additionally, while typical AGILE only calls for user interaction in the final stage, in the case of VR development, it is wise to include professionals to test portions of the application here. This is because VR is, by nature, designed to simulate reality, and user feedback in development prevents wasting development time or money on faulty programming assumptions leading to a VR application that does not simulate reality well enough in the opinion of the eventual users.

Finally, this stage needs to include a means of collecting metadata about the application and its use – not personal information of users, but some means of verifying that user behavior is within acceptable guidelines, to protect other users. This can include voice recordings, chat logs, and other data. If it is kept completely confidential and internal, it is acceptable to use this data to police bad behavior.

4.3.4 Quality Assurance and User Assurance Testing

Finally, these stages of testing need to include a broader subset of the VR user base. Typically, development teams will use signups or volunteers to test out applications prior to release, but this skews the testing base towards well-behaved and enthusiastic individuals. This is where creating a trial version of the VR application serves a second purpose – by releasing a trial for free to the public at large, developers can tell how larger portions of the population will interact within their application, while also allowing users to safely test whether the application is for them. This helps to counter both the ethical implications of inflicting undue mental and physical distress on users, while also allowing VR developers to take initiative to counter unexpected user behavior.

5. ANTICIPATED RESULTS

The desired end state of these modifications to AGILE development is to ensure that developers are considering best practices to address the most prevalent ethical conflicts that do or are likely to

manifest themselves in VR applications without concrete steps taken to address them. Given the lack of established VR development practices, the impact of implementing these development lifecycle changes can vary based on how closely development studios follow AGILE already. However, in a best-case scenario, should these practices be put into place industry-wide, much of the potential user harm would be avoided. VR is currently mostly free of predatory monetization, and companies adopting these modifications would ensure it stays that way, making their applications fun and not aiding in getting users addicted.

Future applications can take lessons learned from VRChat and Bigscreen's failures, taking more initiative to protect users' data privacy and ensuring that users are protected from bad actors who would exploit them, both from stealing their data and acting as predators. Finally, designing applications with more user freedom in mind to modify the intensity and detail of a VR experience significantly reduces the potential negative mental and physical health impacts.

6. CONCLUSION

I designed this project to provide developers with a framework to keep users protected from the most likely ethical issues of new VR programs. Using the most prolific ethical violations in VR programs that have occurred already as a basis, it is not specific to any one application, as VR programs come in a vast array of sizes, quality, and purposes. Instead, it focuses on the ethical questions that any good VR application must address. It further provides developers with the ideal timeframe within the AGILE development cycle to tackle these issues.

Armed with this knowledge, VR developers can be proactive in preventing user harm while reducing the cost and time they must spend implementing these changes, as they fall within the development cycle that developers are already used to. Users will benefit from the increased attention to detail and user protections that VR developers invest into their applications.

7. FUTURE WORK

Future work is needed to improve the portability of the concepts discussed here into a wider array of development lifecycles employed by software development teams. While AGILE is the most common software development method, other software development studios might ignore these findings and suggestions if they are difficult to import into a different method. Additional work is also needed to obtain data on validity and cost of these suggestions. The VR industry is very new, and while this is good for implementing changes to VR software development methods as they have yet to be definitively established, there is not much data to use to make projections on how the suggested AGILE modifications would actually impact cost and development time.

REFERENCES

- [1] Priyanka, R. (2020, May 28). Hacking virtual reality – researchers exploit Bigscreen VR app: Cybersafe News. Latest Cyber Security News, Leading Cyber Security News. Retrieved April 18, 2023, from <https://cybersafe.news/hacking-virtual-reality-researchers-exploit-bigscreen-vr-app/>
- [2] Crawford, A. (2022, February 23). Metaverse app allows kids into virtual strip clubs. BBC News. Retrieved April 17, 2023, from <https://www.bbc.com/news/technology-60415317>
- [3] VRChat (2018, September 26). Vrchat Safety and Trust System.VRChat. Retrieved April 16, 2023, from <https://docs.vrchat.com/docs/vrchat-safety-and-trust-system>
- [4] Parasuraman, S., Sam, A. T., Yee, S. W. K., Chuon, B. L. C., & Ren, L. Y. (2017). Smartphone usage and increased risk of mobile phone addiction: A concurrent study. *International Journal of Pharmaceutical Investigation*, 7(3), 125. <https://doi.org/10.4103/jphi.jphi.56.17>
- [5] Slater, M., Gonzalez-Liencre, C., Haggard, P., Vinkers, C., Gregory-Clarke, R., Jelley, S., Watson, Z., Breen, G., Schwarz, R., Steptoe, W., Szostak, D., Halan, S., Fox, D., & Silver, J. (2020). The ethics of realism in virtual and augmented reality. *Frontiers in Virtual Reality*, 1. <https://doi.org/10.3389/frvir.2020.00001>

- [6] Steinhäusser, S. C., Oberdörfer, S., von Mammen, S., Latoschik, M. E., & Lugin, B. (2022). Joyful adventures and frightening places—designing emotion-inducing virtual environments. *Frontiers in Virtual Reality*, 3. <https://doi.org/10.3389/frvir.2022.919163>
- [7] Grand View Research. (2022, Apr 4). Virtual reality headset market share & growth report, 2030. *Virtual Reality Headset Market Share & Growth Report, 2030*. Retrieved March 19, 2023, from <https://www.grandviewresearch.com/industry-analysis/virtual-reality-vr-headset-market>
- [8] Petrov, C. (2023, January 26). 45 virtual reality statistics that Rock the market in 2023. *Techjury*. Retrieved February 13, 2023, from <https://techjury.net/blog/virtual-reality-statistics/#gref>