

# The Future of Extended Reality (XR)

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This article explores emerging extended reality technologies that are changing the way we work, play and engage with the world around us. We start by exploring the issues that current extended reality technologies possess (challenges and limitations). Secondly, we introduce new concepts in the area of XR (e.g., accessibility and security) and discuss how such concepts are realised in practice. Lastly, we cover some of the state-of-the-art works in this field and discuss the emerging research problems in the area.

## Introduction

Extended reality (XR) technologies have a long history for offering creativity through a wide range of emerging technologies (AR, VR and MR). New technologies hope to bring **extended reality (XR)** capabilities more into the main stream by integrating them more into our lives (e.g., web-based applications, entertainment, engineering and more). How these technologies are exposed, and what capabilities they have, needs to be informed by designers and others with real use-cases in mind. This article explores some of the questions and ideas around the current and future directions XR technologies, such as, expanding XR to support a more comprehensive set of capabilities. This will require additional frameworks and standards to be defined. As part of charting this path forward, the community will also need to decide what will and will not be possible with XR, and in what areas XR will excel [1-4].

## XR Crisis: Building a New World

Are we (the experts) fooling ourselves that our approaches are effective or appropriate to protect users and the public today and for the future XR environments? Are our old recipes still suitable? The XR tools and technologies are rapidly changing, we should realize that approaches and expectations from 10 years ago are obsolete [4,5]. We should try to match the growing expectations of users and consumers through technological development, innovations, and strategies to establish ethical and moral approaches, security measures and tools that will meet both today's and tomorrow's challenges. Change is nothing new in the XR field, and we are used to adapting, evolving, and improving measures to keep up. However, some of the recent and upcoming changes are so fundamental that **incremental improvements no longer seem appropriate**. This will lead to an XR crisis.

## Limitations/Challenges

- Ethical and moral
  - Impact of the experience
  - Type of content and experience
- Technologies
  - Network speeds/security
  - Cost and quality (resolution/processor/aesthetics)
  - Changing standards (consistent/cross-platform)
- Multi-user interaction
  - User safety
  - Open content creation/sharing
- Data collection/analysis (e.g., face/hand recognition)

## Taking XR Threats Seriously

Applying procedures the old-fashioned way can be difficult or even impossible in some cases to XR solutions (e.g., modelling emotional impact, psychological aspect and so on during early phases of development, content and interaction management can in some cases be used to prevent malicious acts). We should not rush to conclude that XR solutions are more/less/equally safe to other interactive applications: the new digital world is the same for both, and they share some of the same challenges. The

point is to start discussing how to manage and develop approaches to tackle the new complexities, dependencies, and dynamics of the XR world today and for tomorrow.

### XR is for more than just Entertainment

For example, science fiction lets us simulate concepts that stretch our imagination, to see what could theoretically happen [5,6]. As time goes by, some challenges and limitations will be removed, such as visual limitations of the content and network speeds, however, other limitations and challenges if left unchecked could cause long term harm (e.g., security, ethical and moral legislation around XR technologies). It is imperative to stay up-to-date with XR advancements which introduce new threats and vulnerabilities. Failing to stay up-to-date puts users and the public at risk. The **extended reality landscape is rapidly changing**, and we need to stay alert to the changing threats so that we can react appropriately [1].

There are many other aspects of XR that challenge the old ways of thinking, from the problem of separating the right facts from fake news; fear, uncertainty, and doubt; and increasingly fast release cycles to managing content and environments that are progressively dependent on millions of devices and sensors that are directly connected to the Internet.

There is also some good news: we are still in the early days of XR, time for developing protocols and systems to protect users and the public, while traditional practices are still valid (e.g., content control and security). We must not become complacent and ignore the road ahead. The automation of XR testing methods and integration of automated release decisions in continuous integration/continuous deployment pipelines can miss dangerous shortcomings [1].

### Anticipating Risks

XR experts are sure to fall behind if we stick to old ways while the world around us is changing. We have to actively challenge some of the existing paradigms (e.g., handle content, user experience and tools), come up with new standards (design to protect against the unknown), focus activities where security matters most, and reevaluate threats and risks (e.g., the hazard of introducing side-effects/mental harm/manipulation). The opportunities that come with new developments (automation) also need to be recognized. There are many good opportunities, but we have to be brave enough in pursuing them, even if the opportunities seem to contradict past experience. Not to mention stunting any creativity or innovation through overly strict regulations.

### Timely Intervention is Vital

Any limitations or regulations are often seen as hindering innovation. Preventing innovators from pushing the boundaries of what's possible (delivering new and original products). On the other hand, management, product owners, and developers are increasingly conscious of and nervous about the risks and dangers of their products. The business damage an XR incident can cause is clearly visible. It becomes even clearer that without convincing safety checks/procedures the dangers to users and the public are ever more prominent [1].

### Protecting Users and Their Data

All it takes is one weak point in the overall system for the integrity of the entire XR system to be compromised. Think of the sheer amount of personal data that an XR application could collect/store and transmit (from biometric information to personal details) that could easily be taken advantage of by unscrupulous people. This data is a goldmine for criminals if it can be reached easily.

### The Importance of Educating Users/Designers

Training can alert users, the public and employees to threats, policies and procedures, and can build up a knowledge base for addressing how to deal with such dangers. The issues can range from accidental breaches from bugs in the code to more explicit concerns, such as, inappropriate content which could be the result of insufficient training or awareness. To ensure high standards no single person should be responsible, safety checks and measures need to be part of day to day operations, from training the public

and companies to never ignore default options and resources offered by 'out of the box software/tools' to training for correct procedures which could potentially compromised users safety/data.

## References

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