RETHINKING ENGINEERING EDUCATION IN IRELAND
REEdI

MTU
Ollscoil Teicneolaíochta na Mumhan
Munster Technological University

SPECIAL TOPIC PRESCRIBED FOR THE LEAVING CERTIFICATE ENGINEERING EXAMINATION 2023

Basic Principles and Applications of Extended Reality (XR)

UNIVERSITY OF LIMERICK
OLLSCOIL LUIMNIGH

HEA HIGHER EDUCATION AUTHORITY
AN tÚDARÁS um ARD-OIDEACHAS

HCI Human Capital Initiative

Foreword

It's apt that this year's leaving certificate prescribed topic is "Basic principles and applications of Extended Reality (XR)" as, we at MTU Kerry Campus host Irelands premier 180-degree curved screen immersive training and education environment. We also have established ourselves as a centre of excellence for the use of XR technology; not only in undergraduate engineering education, but also as part of training and development of staff in the workplace.

Our Bachelor of Engineering (Hons) in Mechanical and Manufacturing Engineering student engineers at MTU Kerry Campus get to experience first-hand these emerging technologies. They use virtual reality (VR) and augmented reality (AR) technologies as standard tools throughout the modules they study on the programme. Every student on this programme gets an Oculus Quest 2 VR headset to allow them to work on engineering projects in VR anytime, anywhere. Our student engineers also have access to Microsoft HoloLens AR glasses. They are currently using the HoloLens to improve and streamline mock production processes as part of a module called "production engineering", which they study in Semester 2 on the programme.

The Bachelor of Engineering (Hons) in Mechanical and Manufacturing Engineering at MTU Kerry Campus (CAO Code: MT834) was designed as part of the REEdI- Rethinking Engineering Education in Ireland project. The REEdI Project is funded through the Higher Education Authorities Human Capital Initiative (HCI) Pillar 3 fund. The goal of this project is to reinvent the way that engineering education is designed and delivered in Ireland. Our agile and innovative engineering programme is the first of its kind in Ireland and the world. We use XR technologies as key learning tools throughout the programme. Student Engineers will spend 2 years on campus in Tralee, County Kerry and then have a choice of world class manufacturing companies to go to for 2 years paid work placement. Our student engineers will bring their XR knowledge and skills with them to our partner companies. Also, we are proud of the support structures we have in place for our student engineers. These include many things-for example- extra maths support, mentoring, online learning supports and access to engineers in residence (who have industry expertise and help prepare our student engineers for their work placement).

If you are interested in an exciting and varied career, a career that will make a difference, a career that will help you to become an engineer of the future, an engineer that can work with different types of teams to develop solutions to the United Nations Sustainable Development Goals (UN-SDGs)- then you should consider the REEdI Engineering degree at MTU Kerry Campus (CAO Code: MT834).

I would like to sincerely thank Hans Moolman, Michael Noctor and Jessica Dennison for their work in pulling together this fantastic leaving certificate support pack for this year's prescribed topic.

Looking forward to meeting all the Student Engineers of the future at MTU Kerry Campus in September 2023!

Dr Fiona Boyle
Head of Department, STEM / Director of the REEdI Project at MTU

What is extended reality (XR)?

Extended Reality (XR) is a group of technologies that enable the merging of the physical and virtual worlds. The three main types of XR are augmented reality (AR), virtual reality (VR), and mixed reality (MR).

Virtual reality (VR) refers to a fully immersive digital experience in which users are completely immersed in a simulated environment. Augmented reality (AR) is a technology that overlays digital information onto the physical world. Mixed reality (MR) is a hybrid of VR and AR that allows digital objects to interact with the real world.

XR has a wide range of applications, including entertainment, education, healthcare, and training. For example, VR can be used for training simulations, while AR can be used for remote assistance and maintenance. MR can be used for design and visualisation.

Extended reality technologies are rapidly advancing and offer a range of exciting possibilities for enhancing our perception of the world and creating new experiences.

What are the basic principles of extended reality (XR)?

Overall, XR is designed to create a more immersive, interactive, and engaging experience for users by bringing together the physical and virtual worlds in a seamless way.
Here are some basic principles of XR:

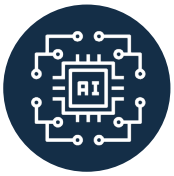
IMMERSION
XR is designed to create an immersive experience for users by surrounding them with a virtual environment that feels real.

PRESENCE
XR strives to create a sense of presence for users, making them feel as if they are actually present in the virtual environment.

INTERACTIVITY
XR allows users to interact with the virtual environment in real-time, often through the use of hand gestures, voice commands, or other forms of input.

REAL-TIME FEEDBACK
XR provides real-time feedback to users, allowing them to see the results of their actions in the virtual environment immediately.

SPATIAL COMPUTING
XR uses spatial computing to track the user's movements and adjust the virtual environment accordingly, creating a more realistic and immersive experience.



ARTIFICIAL INTELLIGENCE
XR can incorporate artificial intelligence to create more realistic and intelligent virtual characters and environments.

SENSORY ENGAGEMENT
XR incorporates sensory engagement to create a more realistic experience for users, including visual, auditory, and haptic feedback.

What are the applications of extended reality (XR)?

Extended reality has a wide range of applications across various industries and fields. Here are some examples:

EDUCATION

XR can be used to create educational content that allows students to visualise complex concepts in a more engaging way. For example, the BEng. (Hons) in Mechanical and Manufacturing Engineering at MTU Kerry challenges first year student engineers to create a Rube Goldberg machine in virtual reality.

ENTERTAINMENT

XR is used in video games, theme parks, and other forms of entertainment to create immersive experiences for users.

HEALTHCARE

XR is used in healthcare to create virtual simulations for medical training and to help patients cope with pain and anxiety during procedures.

ARCHITECTURE AND ENGINEERING

XR is used in architecture and engineering to create 3D models of buildings and structures that can be explored in VR before they are built.

MARKETING AND ADVERTISING

XR can be used to create immersive marketing campaigns that allow users to experience products and services in a more engaging way.

RETAIL

XR can be used to create virtual stores where customers can browse and purchase products in a more immersive and interactive way.

TOURISM

XR can be used to create virtual tours of destinations and attractions, allowing users to experience them from anywhere in the world.

MILITARY AND DEFENCE

XR can be used to create simulations for military training, allowing soldiers to practice scenarios in a safe and controlled environment.

In summary, XR has a wide range of applications and is expected to become increasingly important in the coming years as technology continues to advance.

What is the difference between Augmented Reality (AR) and Virtual Reality (VR)?

Augmented Reality (AR) and Virtual Reality (VR) are both technologies that aim to create immersive experiences for users, but they do so in different ways.

AR is designed to enhance the real-world environment by overlaying digital information or objects onto it. AR typically involves the use of a device such as a smartphone or a headset that is equipped with a camera and sensors that can track the user's movements and the surrounding environment. AR technology can recognise and track real-world objects and use this information to overlay digital content on top of them.

In contrast, VR is designed to create a completely artificial environment that simulates the real world or an imaginary one. VR typically involves the use of a headset that completely blocks out the real world and immerses the user in a virtual environment. The headset may also be equipped with sensors that track the user's movements, allowing them to interact with the virtual environment in a more natural and intuitive way.

Overall, the main difference between AR and VR is that AR enhances the real world by overlaying digital content onto it, while VR creates a completely artificial environment that immerses the user in a virtual world.

Explain the term Mixed Reality (MR)?

Mixed Reality (MR) is a type of technology that blends elements of both Augmented Reality (AR) and Virtual Reality (VR) to create a new kind of immersive experience. MR aims to create a seamless integration of virtual and physical worlds, allowing digital objects to interact with real-world objects and vice versa.

MR works by overlaying digital content onto the real world, much like AR. However, unlike AR, MR allows the digital content to interact with the real-world environment and objects in a more realistic way. This is achieved through the use of advanced sensors and cameras that can track the user's movements and the surrounding environment, allowing the digital content to be positioned and rendered in 3D space. In addition, MR also allows users to interact with the digital content in a more natural and intuitive way. Users can use gestures, voice commands, or physical objects to manipulate and interact with the virtual objects in the real world.

Overall, MR offers a new level of immersion and interactivity that is not possible with either AR or VR alone. It has numerous applications in fields such as gaming, education, healthcare, and engineering, and has the potential to revolutionise the way we interact with digital content and the real world.

What are the applications of virtual reality in the manufacturing industry?

Virtual reality (VR) has many applications in the manufacturing industry, from design and prototyping to assembly and training. Here are some examples of the use of VR in manufacturing:

DESIGN AND PROTOTYPING

VR can be used to create 3D models of products and simulate their functionality before they are built, allowing for more efficient and cost-effective design and prototyping.

ASSEMBLY AND MAINTENANCE

VR can be used to simulate assembly and maintenance procedures, allowing workers to practice and improve their skills in a safe and controlled environment.

QUALITY CONTROL

VR can be used to simulate quality control processes and identify potential issues before products are manufactured, reducing the risk of defects and increasing efficiency.

SAFETY TRAINING

VR can be used to simulate hazardous working conditions and train workers on safety procedures, reducing the risk of accidents and injuries.

REMOTE COLLABORATION

VR can be used to enable remote collaboration between designers, engineers, and manufacturing teams, allowing for more efficient communication and collaboration across different locations.

SALES AND MARKETING

VR can be used to create immersive product demonstrations and presentations, allowing customers to experience products in a more engaging way.

Overall, VR has many applications in the manufacturing industry and can help improve efficiency, safety, and quality across various stages of the manufacturing process.

What are the applications of Augmented Reality for engineering?

Augmented Reality (AR) has numerous applications in engineering and can help engineers visualise and interact with designs in new and innovative ways. Here are some examples of the uses of AR for engineering:

DESIGN VISUALISATION

AR can be used to create 3D models of products and visualise them in the real world, allowing engineers to see how they will look and function in the physical environment.

MAINTENANCE AND REPAIR

AR can be used to overlay digital instructions and diagrams onto physical equipment, making it easier for engineers to diagnose and repair issues.

TRAINING AND SIMULATION

AR can be used to create immersive training simulations that allow engineers to practice and improve their skills in a safe and controlled environment.

QUALITY CONTROL

AR can be used to identify and highlight defects in products or equipment, making it easier for engineers to identify and address quality control issues.

REMOTE COLLABORATION

AR can be used to enable remote collaboration between engineers and other team members, allowing for more efficient communication and collaboration across different locations.

ASSEMBLY AND MANUFACTURING

AR can be used to overlay digital instructions onto physical components, making it easier for engineers to assemble and manufacture products more efficiently and with fewer errors.

In conclusion, AR has many applications in engineering and can help improve efficiency, safety, and quality across various stages of the engineering process.

Discuss how the development of hardware such as headsets and the continuous improvement of computer chips has enabled extended reality applications.

The development of hardware such as headsets and the continuous improvement of computer chips have been critical to the emergence and widespread adoption of extended reality (XR) applications, including virtual reality (VR), augmented reality (AR), and mixed reality (MR).

Headsets, in particular, have been a key component in enabling immersive VR experiences. Early VR headsets used heavy and bulky hardware, but advancements in miniaturisation and wireless connectivity have allowed for the development of more lightweight and mobile headsets that can deliver high-quality VR experiences. For example, the Oculus Quest 2 VR headset uses a combination of powerful processors and high-resolution displays to create immersive VR environments, all while being wireless and portable.

Computer chips have also played a crucial role in enabling XR applications. The development of more powerful CPUs and GPUs has allowed for the creation of more complex and realistic virtual environments, as well as enabling AR and MR applications that require real-time processing of data. For example, the Microsoft HoloLens 2 MR headset uses a custom-built Microsoft Holographic Processing Unit (HPU) to process real-time data from multiple sensors, providing users with a seamless and interactive AR experience.

Advancements in chip technology have also enabled the development of specialised processors designed specifically for XR applications. For example, Qualcomm's Snapdragon XR2 platform is specifically designed for VR and AR applications, providing high-performance computing capabilities and advanced features such as eye-tracking and hand tracking.

Advancements in artificial intelligence (AI) and machine learning (ML) have also played a role in the development of XR applications. These technologies can be used to analyse and interpret data from sensors and cameras, allowing for more precise tracking and interaction within XR environments.

In addition, the continued miniaturisation of hardware components such as sensors and cameras has enabled XR devices to become more portable and accessible. This has opened up new opportunities for XR applications in fields such as education, healthcare, and entertainment.

The development of hardware such as headsets and the continuous improvement of computer chips have been crucial in enabling the growth of XR applications. As these technologies continue to evolve, we can expect to see even more innovative and immersive XR applications in the future.

What is the Metaverse and how it is linked to extended reality?

The metaverse is a term used to describe a hypothetical future iteration of the internet that is entirely immersive and interactive, allowing users to engage with a fully-realised virtual world. It is essentially a virtual universe made up of interconnected virtual spaces, experiences, and objects, which can be accessed and interacted with by anyone from anywhere in the world.

In the metaverse, users can create and customise their own avatars, explore digital environments, participate in virtual communities, and engage in a wide range of activities, from gaming and entertainment to education and commerce. The metaverse is expected to be built on a range of emerging technologies, such as virtual reality, augmented reality, blockchain, and artificial intelligence.

While the metaverse is still largely a concept, there are already many examples of virtual worlds and online communities that share some of its characteristics. Some experts believe that the development of the metaverse could have a profound impact on society, transforming the way we work, learn, socialise, and interact with the digital world.

In the context of the metaverse, XR technologies are expected to play a significant role in enabling users to fully immerse themselves in virtual environments. For example, VR headsets can transport users to entirely digital worlds, while AR and MR can overlay digital content onto the physical world, creating a mixed reality experience.

As the metaverse evolves, XR technologies are likely to become more sophisticated and integrated, allowing users to interact with digital objects and avatars in increasingly lifelike ways. This could include using haptic feedback to simulate physical touch, or using eye-tracking and other technologies to create more natural interactions between users and virtual objects.

XR is an important component of the metaverse, as it enables users to experience digital content in a more immersive and engaging way, blurring the lines between the physical and digital worlds.

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