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Introduction

Our modern society is undergoing a digital revolution. Digital areas are constantly evolving to support people's everyday lives. Revolutionary changes in the technologies becoming available to ordinary people have filtered through to everyday life, from digital payment methods to the virtual world of everyday transactions. Information is virtually present everywhere in people's environment. We see information in our natural environment, for example about animals, roads, other people, as well as in artificially created environments such as our digital devices (be it a phone, a tablet, or a desktop computer). So information is virtually everywhere, en masse.

There are many technologies available today to perform information-related activities. The collection, storage, processing, modification, refinement and transmission of information can nowadays be supported by a variety of devices and their networked systems. It cannot be argued that without these infocommunication networks, our society would have great difficulty functioning. It is no coincidence that our current information-centric society is called information society.[1] In our information society, the development and modernisation of infocommunication technologies is significant and particularly intensive; moreover, the related needs and requirements are constantly changing. In the context of information protection, the term cyberspace and related concepts are widely and well known, all of which are the result of the expansion and development of the information space. In cyberspace, there is a multitude of operational possibilities that arise from the interconnection and interaction of the real and the artificially created virtual spaces.

Nowadays, virtual spaces pervade our society and have a significant impact on our society in many ways. As it is true in real space, so it is in virtual spaces, sharing and living experiences have become a natural need in everyday life. In order to be part of a virtual community, it is required that people create a virtual entity of their own personality. Among the related technological developments, the immersive technologies stand out. In the sense of immersive technologies,

[1] "An information society is a society where the creation, distribution, use, integration and manipulation of information is a significant economic, political, and cultural activity. The aim of the information society is to gain competitive advantage internationally, through using information technology in a creative and productive way" (Definitions.net: *Information Society.* s. a.).

virtual reality, augmented reality, mixed reality and extended reality are to be discussed. All four areas are quite popular, especially virtual reality and augmented reality. Immersive technologies are of particular interest to people because they can provide experiences that real space cannot or can only partially provide to them. It is important to note that virtual environments already have and will continue to have a significant impact on people's everyday lives, and it is therefore useful to consider and interpret the technologies involved in several ways. Such multiple approaches will of course help to create a comprehensive picture of the features and capabilities of each of the technologies mentioned, thus helping the people to appropriately balance the use of these virtual spaces and the real space at the same time. In order to achieve this goal, this document will also take a number of so-called perspectives to address what is considered to be the more relevant knowledge of these technologies in question. The versatile and detailed study of immersive technologies is clearly beneficial, independently whether you are a single user of them, a developer of environments based on such technologies, or otherwise interested in this field.

Virtual reality is extremely popular and it is natural that users do not pay much attention to the deeper level of understanding of the technology beyond the experience. Following this line of thought, the next chapters will introduce virtual reality and related immersive technologies from different perspectives, with a variety of concepts and interpretations. After presenting the historical background of virtual reality, the main technological basics, the related technologies and the possible future direction will be discussed.

The economic, development and social perspectives have been selected for the study of immersive technologies. Currently, there are few documents in which one can read about the multiple perspectives on virtual reality in one place, even though the technology (virtual space) has many implications for society. In addition to the understanding of immersive technologies, it is important to note that a number of potential societal impacts can and should be considered in their application. As these are products that represent innovation, it is only natural to look at various statistical indicators and to assess their economic potential. The economic approach also involves looking at the products that are considered to be important, which is why three products from different well-known companies have been selected to provide the reader with an insight into their basic characteristics. From a developer's point of view, a deeper understanding of virtual and augmented reality as two of the most popular technologies and the design

and development testing processes and methodologies required to develop the immersive technology itself are specifically discussed. As with all development, the existence of an appropriate development environment is essential for these technologies. In addition to this, social technology assessment is also important because it is worthwhile to design and implement features that are beneficial to this area. In addition, it is also important to take a social approach because, although often unspoken, it is essential to be aware of the feelings that the human brain has about the world of reality (the natural environment). Personal behaviours in virtual environments today clearly shape people's mental states and personalities, resulting in similar behaviours in real environments. By creating feelings, colours, shapes, sounds, virtual reality helps the human brain to discover previously hidden connections in complex data sets. Users will be able to collect, store, process and transmit information faster and more flexibly. Pervasive technologies can be seen as a milestone for information services, as they enable the artificial extension and augmentation of the real space information environment and systems in our everyday lives. There is a growing interest worldwide in the potential applications of this technology, of which several examples are presented in this paper.

In addition to the civilian applications, it is important to highlight the potential military applications of these technologies, which are dealt with separately in this document. Military operations are also surrounded by a vast amount of information and, of course, a very large number of information communication tools and systems. Military developments are clearly intense in our society today, particularly in the quest for continuous modernisation and innovation. The second half of this study therefore focuses on potential military applications in the context of the use of immersive technologies. After a brief introduction, related development areas of specific interest to military capabilities are examined, as well as different military sectors and units with specific ideas to share with the reader.

By studying virtual reality and with it, immersive technologies for civilian and military purposes, the aim is clearly to provide the reader with a comprehensive picture. As a final result, what follows is a great starting point for those interested in the field of immersive technologies, in terms of multiple approaches. Therefore, as described below, the document can be taken both as a guide with conclusions and as a technology overview.

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Historical overview of virtual reality

The historical overview of virtual reality can be linked to the need and process of virtualisation; therefore, it is worth saying a few words about the emergence of the needs and conceptual interpretation of the field. It is a technology that is now quite popular and its everyday use has become natural. But let us stop here for a question: What does virtualisation actually mean? It seems natural, yet the more people you ask, the more answers you get. Virtualisation is defined as follows: "Virtualization is the creation of a virtual – rather than actual – version of something, such as an operating system (OS), a server, a storage device or network resources."[2] Virtualisation is an activity that does not take place in physical space, it is not a tangible process. Many people think of it as an extension of physical space, an approach that comes quite close to lumping the needs of virtualisation together in this thinking. In order to make virtualisation as a whole easier to understand (from its inception to the emergence of today's modern technologies), it is useful to look at the main aspects of virtualisation, starting with the needs, which can be divided into two main areas:

- the need for virtualisation of computing resources
- the need to create virtual reality, virtual space

With the development of electronic components, computers with ever-increasing computing power have come onto the market. Components became smaller and smaller and at the same time, more and more capable. The evolution of data collection, storage, processing and transmission functions has led to an increasing variety of needs. Pushing the limits of computers' capabilities, there is a need for more efficient use of resources, which is now a well-known virtual solution. To make efficient use of computing power, seven main components can be virtualised: desktop, server, storage, network, application, hardware and the operation system.

Desktop virtualisation allows multiple virtual machines to run desktops on the same physical and virtual server. Server virtualisation allows management in a cloud. It creates a virtual server in a physical computer. Storage virtualisation reducing costs associated with space in a centre. The network virtualisation uses physical and virtual components at the same time to create a hybrid network and

[2] Visible Stars: *Virtualization.* s. a.

make efficient administration of the network (through software switches). The application virtualisation helps to create a virtual instance of the applications (needed for business) to keep app software off from the local operating system. Finally, the hardware virtualisation aims to make and run different operating systems (creation of virtual machines) on the same hardware. It allows to use the processor simultaneously by more than one user. In addition to all this, a special type of virtualisation is the operation system virtualisation, that can run multiple operation systems instead of having a dedicated server for each system. Virtual environments and virtual spaces are becoming more and more natural for the efficient use of resources, especially for operational tasks. The efficiency of virtually shared resources has certainly contributed to the evolution of the way of thinking about virtual space. The development of virtual services has been accompanied, so to speak, by an examination of the dimensional potential of virtual space. Clarifying the functional needs of virtual space and exploring possible platforms for it are essential measures for the development of the technology. Virtual space, and with it virtual reality, is currently considered a cutting-edge technology, but the history of its development goes back much further than many people realise. It is important to note that the two main trends in the development of virtual solutions is to make computing resources more efficient, and the development of virtual reality are parallel to each other. In the following, detailed main historical events of virtual reality are described.

The first related device was certainly the stereoscopic dissipative (also called mirror stereoscope), invented by Sir Charles Wheatstone in 1838, which can be considered the predecessor of head mounted displays. The invention as you can see in Figure 1 allowed users to see a separate image in each eye (see E and F marks on the picture) creating a wider, three-dimensional image.

Many years later, in the early 1900s, the advent of aeroplanes would see further claims close to the technology. The ancestor of educational flight simulators was made a reality by Edwin Link. The simulator provided cockpit exposure and pneumatic pumps that gave an artificially created sense of the flight environment, a realistic experience for pilots. Training systems can support skills development, practice and maintenance in an efficient way (location, time, equipment, running costs) by complementing the traditional training tools.

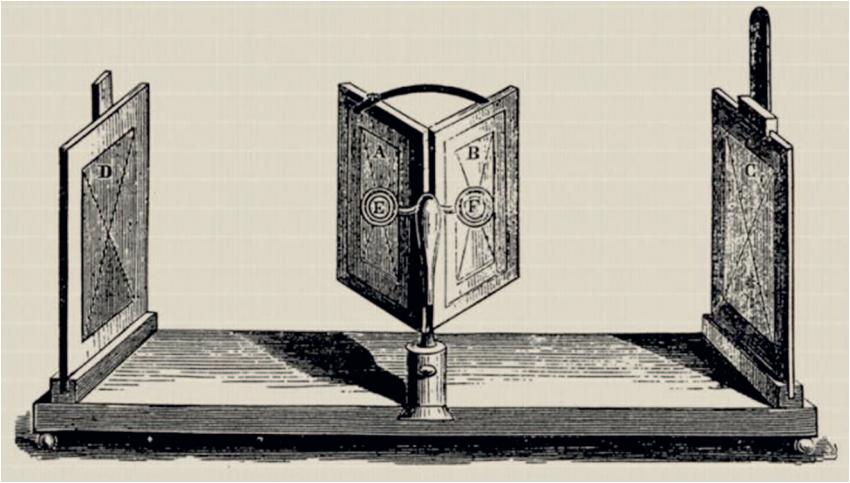

Figure 1: The stereoscopic dissipative
Source: Duncan (2019): op. cit.

This has proved to be beneficial, as pilots have been able to develop their skills without actually using an aircraft. It is therefore important to stress that the military application of this technology has also begun to be intensively applied. "In 1929 Edward Link created the "Link trainer" (patented 1931) probably the first example of a commercial flight simulator, which was entirely electromechanical. It was controlled by motors that linked to the rudder and steering column to modify the pitch and roll. A small motor-driven device mimicked turbulence and disturbances. Such was the need for safer ways to train pilots that the US military bought six of these devices for $3500."[3] As a point of interest, in 1930 Stanley Grauman Weinbaum presented a science fiction story linked to technology, Pygmalion's Spectacles. In the story, the author imagined a pair of spectacles that would allow virtual experiences of sight, touch, smell and taste. It is important to emphasise, after the initial focus on vision as a perception, the focus has increasingly shifted to the study of the other human senses. The initial testing of the senses in an artificial environment has led to further technological developments.

[3] Virtual Reality Society: *History of Virtual Reality.* s. a.

The 1950s was a very important period for the capabilities (creative ideas and initial implementations) of immersive technologies as we know them today. One example in civilian applications is the theatre cabinet Sensorama, which was designed by Morton Heilig. The aim was to immerse the user completely in the film, using stereo speakers, a stereoscopic 3D display, odour generators, fans and a vibration chair, among other things. The Sensorama in Figure 2 was called the cinema of the future. The product was accompanied by short films such as Belly Dancer, Motorcycle, Dune Buggy.

Figure 2: The theatre cabinet, Sensorama
Source: Jeremy Norman's HistoryofInformation.com (s. a.): op. cit.

In the 1960s, the development of technology began to intensify, based on earlier ideas. The real breakthrough for virtual reality products was Morton Heilig's patented invention of the Telesphere Mask in 1960, the world's first head-mounted

display. The invention had three-dimensional, widescreen images and stereo sound (stereoscopic technology), which gave rise to many new ideas for many people interested in technology. It is important to note here that virtual reality and augmented reality, two popular development trends today, are presumably based on the later idea of both the abovementioned, and have started to develop for both civil and military applications. "The history of VR has often been influenced by the defense industry. One of the first VR projects was developed in the 1960s for a US military combat system. Virtual reality has always played a significant role in the military and was adopted by all services: army, navy, and air force. It is mostly used for army training purposes, but there are other use cases where VR is a powerful tool."[4] At this time, the analysis of user experience needs and the mapping of related technological capabilities were already going on in parallel and intensively.

Among the developments of the 1960s, it is important to highlight the appearance of the first motion tracking system, which was implemented in 1961 as the "Headsight" product developed by the Philco Corporation. The product was not developed to create virtual reality, but it allowed for getting realistic experience, particularly military operations. The two main components of the product were a video screen for both eyes and a magnetic motion tracking system linked to a camera. Later, in 1965 computer scientist Ivan Sutherland presented his vision of the Ultimate Display. The concept aims to reproduce reality so that the user cannot distinguish between the actual reality and the virtual reality created. It is important to note that this interaction between man and machine has become a key factor in the development of technology. Around the world, documentation written at this time is seen as the basic blueprint for virtual reality. In 1969, Myron Krueger (considered the computer artist of virtual reality) described his experiences with projects such as Glowflow, Metaplay and Psychic Space, Videoplace, which were major advances, particularly in the development of the so-called "Videoplace" technology.

In the 1970s, aircraft simulators continued to evolve. In 1972 General Electric started to produce a computer flight simulator. The Videoplace project shown in Figure 3 led by Myron Krueger, opened up further and quite new possibilities for human–machine interaction. Research during this period can be seen as an artistic exploration of visual experiences. As you can read about the project: "Videoplace consists of two rooms that could be in the same building or on

[4] Sandrine Laserre: *4 Use Cases for Virtual Reality in the Military and Defense Industry.* 2021.