Market, Technology and Standard Requirements of VR

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1 Introduction

Virtual reality (VR) is an integrated technology based on computer technology, which uses VR headsets or multi-projected environments, sometimes in combination with physical spaces, to generate realistic images, sounds and other sensations that simulate a user's physical presence in a virtual or imaginary environment. A person using VR equipment is able to "look around" the artificial world, move about in it and interact with virtual features or items. The effect is commonly created by VR headsets consisting of head-mounted goggles with a screen in front of the eyes, but it can also be given through specially designed spaces with multiple large screens.

VR systems that include transmission of vibrations and other sensations to the user through a game controller or other devices are known as haptic systems. This tactile information is generally known as feedback in applications as medical, video gaming and military training. VR also refers to remote communication environments which provide a virtual presence of users through telepresence or the use of a virtual artifact (VA). The immersive environment can be similar to the real world in order to create a lifelike experience grounded in reality.

In this report, we try to figure out the market trend of VR equipment, the technologies included in VR, then the most important part, we try to give a overview of the standard framework of VR, which will show the items and relationship for the standard projects we should considered. Find out the hot topics for TC100.

As we all know, Augmented Reality (AR) and Mixed Reality (MR) sometimes will be mentioned together with VR, but this report only focus on the issues of VR, in order to make things to be simpler and easier. All the material can be referenced to the technical report about standard requirements of AR/MR, which may be given later.

2 Overview of VR technology

2.1 What is VR

Now a days, Virtual Reality (VR) is one of the top hot words in all fields, this report is trying to gather useful information about marketing and technical trend in field of VR.

In a simple way, VR means experiencing things through our computers that don't really exist. Based on this simple definition, chasing for a more virtual experience through eyes is not a new idea. Even in thousand years ago, the amazing artists had tried to show a “real world” before the audience using colors and lights. Can it be regarded as the very first trail for VR?

Virtual reality (VR) is a computer-based technology, sometimes in combination with physical spaces or multi-projected environments, to generate realistic images, sounds and other sensations that simulate a user's physical presence in a virtual or imaginary environment. A person using virtual reality equipment is able to "look around" the artificial world, and with high quality VR move about in it and interact with virtual features or items.

Now a days, there exist several different kinds of terminal equipment, but VR headset is still the most popular one, which is head-mounted goggles with a screen in front of the eyes. Programs may include audio and sounds through speakers or headphones.

Figure 1 Different types of VR equipment/system

2.2 What included in VR research domain?

When we talk about VR technology, what are we really talking about? VR is a typical integrated tech, which may have overlaps with several techniques, including

- electronics,
- psychology,
- auto control,
- computer graphics,
- database,
- distribution system,
- audio, video and multimedia,
- etc.

Within the scope of TC100, it is necessary to find out the standardization requirements of VR technology, which is not included in the scope of other TCs.

2.3 Customer Requirements

Compare with other technology which intend to show a real world before audience, customers will have special requirements to VR equipment, which identify VR with other 3D techniques.

- Immersive: Immerse is the basic feature for all VR equipment and system. VR needs to engage both the body and the mind of viewer, to feel the real and to response as in real. As mentioned in the first paragraph, paintings may bring real vision experience to the audience, but they can never fully convey the sight, sound, smell, taste and feel.

- Believable: The final aim of a VR equipment is to give a feel of “being in real world” as the user is actually in a virtual world (eg. in a cave, or wherever) and to keep believing that, or the illusion of virtual reality will disappear.

- Interactive: A “qualified” VR equipment can encourage the interactive between the viewer and the virtual world he is in. As the viewer moves around, the virtual world needs to move with him. This is a quite unique experience compared with watching a 3D movie, the latter can make the viewer to be transported up to the Moon or down to the seabed—but it's not interactive in any sense.

- Response time: Why is this important? A remarkable delay will make the viewer has uncomfortable illusion in the virtual world. Also a powerful processor to deal with high quality 3D computer graphics, it should be fast enough to make believable, interactive, alternative world that change in real-time.

- Explorable: A VR world needs to be big and detailed enough for you to explore. However realistic a painting is, it shows only one scene, from one perspective. A book can describe a vast and complex "virtual world," but you can only really explore it in a linear way, exactly as the author describes it.

VR equipment and system became And concern with the equipment and system, the customer may have some requirements

3 Market of VR equipment

In 1980s, coming of 3D games, as Virtuality and Vortual Boy, had gathered the attention to virtual display techniques. Even some movies, like Lawnmower Man and Virtuosity, and books, as Snow Crash, showed the ideas of VR. But the technology is far from the imagination of people, poor imagine quality, significant latency and high device price made the first trail of VR product to a fail in the end.

Since 2014, the second wave for VR technology came, like most new technologies and platforms, VR has had a rocky but predicable start.

According to the predict of Digi-Capital, the potential market of VR hardware/software will be $120 billion, Superdata predicted that by the end of 2017, only VR headset will be sold out for 70 million sets, made a market of $8.8 billion on hardware and $6.1 billion on software. TrendForce predicted that the VR market will keep a rapid growth in the next 5 years.

3.1 Market in China

In China, there are two kinds of companies in VR market.

One is the mature companies extended their product categorizes from traditional CE products to VR equipment. Lenovo cooperated with ANTVR to develop VR glass, which is a wearable VR headset. MEIZU also cooperated with SHITUO Technology to develop the headset VR for mobile phones. These companies had strong background in smartphone or IT bussiness. Some companies, such as iQiyi and Youku, they start VR bussiness based on the platform of game/video/other contents.

The other kind of companies are grand new ones, they tried to set up a eco platform for VR bussiness at the time they set up the companies. Tencent and Matrix (which belongs to Storm Tech Group) gained success based on their plentiful content resource.

3.2 Market in U.S.

Supply constraints limited access to headsets like the Oculus Ri in 2016, holding back both hardware and software revenue, but these issues have largely been resolved. Greater availability of both headsets and compelling content will drive consumers to spend more this year.

Already the market is solidifying as consumers become increasingly aware of, and comfortable with, the devices. Light mobile headsets like Google's Cardboard will see 30% reduction in shipments in 2017, while premium devices will triple. Greater penetration of quality devices will open this massive new audience to a swath of new content and applications. The challenge for content creators, then, is understanding who the audience is and what they want.

As shown in a report of SuperData's VR Data Network,
- Eighty-three percent (83%) of PC VR users have the space for room-scale VR.
- Male millenniums are most likely to use console headsets over any other device (52%) since 3 in 4 are game players.
- Forty-eight percent (48%) of females over 35 try headsets at home, often using a family member's device.
- Retail demos are the most popular way American consumers become interested in VR before buying.

3.3 Market in Europe

Need to be competed.

3.4 Market in Japan

Need to be completed.

4 Typical use cases of VR equipment

VR has always suffered from the perception that it's little more than a glorified arcade game—literally a "dreamy escape" from reality. In that sense, "virtual reality" can be an unhelpful misnomer; "alternative reality," "artificial reality," or "computer simulation" might be better terms. In the last 30 years, VR technology have been used by scientists, doctors, dentists, engineers, architects, archaeologists, and the military, and it was just been well known by common customers.

4.1 Education and training

VR is used to provide learners with a virtual environment where they can develop their skills without the real-world consequences of failing. It has also been used and studied in primary education.

- Military uses

Thomas A. Furness III was one of the first to develop the use of VR for military training when, in 1982, he presented the Air Force with a working model of his virtual flight simulator the Visually Coupled Airborne Systems Simulator (VCASS). The second phase of his project, which he called the "Super Cockpit", was even more advanced, with high resolution graphics and a responsive display. Furness III is often credited as a pioneer in virtual reality for this research. The Ministry of Defense in the United Kingdom has been using VR in military training since the 1980s. The United States military announced the Dismounted Soldier Training System in 2012. It was cited as the first fully immersive military VR training system.

- Space training

NASA has used VR technology for twenty years. Most notable is their use of immersive VR to train astronauts while they are still on Earth. Such applications of VR simulations include exposure to zero-gravity work environments and training on how to spacewalk. Astronauts can even simulate what it is like to work with tools in space while using low cost 3D printed mock up tools.

- Flight and vehicular applications

Flight simulators are a form of VR pilot training. They can range from a fully enclosed module to a series of computer monitors providing the pilot's point of view. By the same token, virtual driving simulations are used to train tank drivers on the basics before allowing them to operate the real vehicle. Similar principles are applied in truck driving simulators for specialized vehicles such as firetrucks. As these drivers often have less opportunity for real-world experience, VR training provides additional training time.

- Medical training

VR technology has many useful applications in the medical field. Simulated surgeries allow surgeons to practice their technical skills without any risk to patients. Numerous studies have shown that physicians who receive surgical training via VR simulations improve dexterity and

performance in the operating room significantly more than control groups. Through VR, medical students and novice surgeons have the ability to view and experience complex surgeries without stepping into the operating room. On April 14, 2016, Shafi Ahmed was the first surgeon to broadcast an operation in virtual reality; viewers followed the surgery in real time from the surgeon's perspective. The VR technology allowed viewers to explore the full range of activities in the operating room as it was streamed by a 4K 360 fly camera.

4.2 Scientific visualization

Anything that happens at the atomic or molecular scale is effectively invisible unless you're prepared to sit with your eyes glued to an electron microscope. But suppose you want to design new materials or drugs and you want to experiment with the molecular equivalent. That's another obvious application for VR. Instead of wrestling with numbers, equations, or two-dimensional drawings of molecular structures, you can snap complex molecules together right before your eyes. This kind of work began in the 1960s at the University of North Carolina at Chapel Hill, where Frederick Brooks launched GROPE, a project to develop a VR system for exploring the interactions between protein molecules and drugs.

VR offers social scientists and psychologists a cost-effective tool to study and replicate interactions in a controlled environment. In addition, VR enables a new form of perspective-taking by allowing an individual to embody the form of a virtual world. Researchers have used the immersion of VR to investigate how digital stimuli can alter human perception, emotion and physiological state, and how digital interaction can enact social change in the physical world.

- Altering perception, emotion and physiological state

Studies have considered how the form we take in VR can affect our perception and actions. One study suggests that embodying the body of a young child can influence perception of object sizes such that objects are perceived as being much larger than if the objects were perceived by an individual embodying an adult body. These works suggest that immersive VR can create body-transfer illusions capable of influencing how humans respond to different circumstances.

Research exploring perception, emotions and physiological response within VR suggest that controlled virtual environments can alter how a person feels or responds to stimuli. For example, a controlled virtual environment of a park coupled with a strong perceived feeling of presence cause an individual to feel anxious or relaxed. Similarly, simulated driving through areas of darkness in a virtual tunnel can induce a fear response in humans. Social interaction with virtual characters in a virtual environment has been shown to produce physiological responses such as changes in heart rate and galvanic skin response. Individuals with high levels of social anxiety were found to have larger changes in heart rate than their more socially confident counterparts.

The sense of presence in virtual reality is also linked to the triggering of emotional and physiological response. Research suggests that a strong presence can facilitate emotional response, and this emotional response can further increase one's feeling of presence. Similarly, breaks in presence (or a loss in the sense of presence) can cause physiological changes.

- Understanding bias and stereotypes

Researchers have used embodied perspective-taking in VR to explore whether changing a person's self-representation may help in reducing bias against particular social groups. However, the nature of the relationship between embodiment and implicit bias is not yet clear as studies have demonstrated contrasting effects.

4.3 Industrial design and architecture

Architects used to build models out of card and paper; now they're much more likely to build virtual reality computer models you can walk through and explore. By the same token, it's generally much cheaper to design cars, airplanes, and other complex, expensive vehicles on a computer screen than to model them in wood, plastic, or other real-world materials. This is an area where VR overlaps with computer modeling: instead of simply making an immersive 3D visual model for people to inspect and explore, you're creating a mathematical model that can be tested for its aerodynamic, safety, or other qualities.

- Engineering

The use of 3D computer-aided design (CAD) data was limited by 2D monitors and paper printouts until the mid-to-late 1990s, when video projectors, 3D tracking, and computer technology enabled a renaissance in the use 3D CAD data in virtual reality environments. With the use of active shutter glasses and multi-surface projection units immersive engineering was made possible by companies like VRcom and IC.IDO. VR has been used in automotive, aerospace, and ground transportation original equipment manufacturers in their product engineering and manufacturing engineering . VR adds more dimensions to virtual prototyping, product building, assembly, service, performance use-cases. This enables engineers from different disciplines to view their design as its final product. Engineers can view the virtual bridge, building or other structure from any angle. As well, some computer models allow engineers to test their structure's resistance to winds, weight, and other elements. Immersive VR engineering systems enable engineers to see virtual prototypes prior to the availability of any physical prototypes.

- Architectural and urban design

One of the first recorded uses of virtual reality in architecture was in the late 1980s when the University of North Carolina modeled its Sitterman Hall in a virtual environment.

By 2010, VR programs were developed for urban regeneration, planning and transportation projects.

4.4 Games and entertainment

From flight simulators to race-car games, VR has long hovered on the edges of the gaming world—never quite good enough to revolutionize the experience of gamers, largely due to computers being too slow, displays lacking full 3D, and the lack of decent HMDs and data gloves.

- Video games

Several VR head mounted displays (HMD) were released for gaming during the early-mid 1990s. These included the Virtual Boy developed by Nintendo, the iGlasses developed by Virtual I-O, the Cybermaxx developed by Victormaxx and the VFX1 Headgear developed by Forte Technologies. Other modern examples of narrow VR for gaming include the Wii Remote, the Kinect, and the PlayStation Move/PlayStation Eye, all of which track and send motion input of the players to the game console somewhat accurately.

Commercial headsets released for VR gaming include the Oculus Rift and the HTC Vive. Systems in development include Sony's PlayStation VR, requiring a PlayStation instead of a PC to run VR games.

Following the widespread release of commercial VR headsets in the mid-2010s, several VR-specific and VR versions of popular video games have been released. Since 2013, there have been several VR accessory devices that seek to enter the market to enhance the game experience.

Some companies are adapting VR for fitness to encourage exercise.

- Cinema and entertainment

Films produced for VR permit the audience to view a 360 degree environment in every scene. Production companies, such as Fox Searchlight Pictures and Skybound, utilize VR cameras to produce films and series that are interactive in VR.

In September 2016, two announcements were made for broadcast of sporting events in VR. The telecasts (which use roughly 180 degrees of rotation) were made available through smartphone apps and head-mounted displays, through a TV Everywhere paywall.

Since 2015, VR equipment has been installed onto a number of roller coasters and theme parks, including Galactica at Alton Towers, The New Revolution at Six Flags Magic Mountain and Alpenexpress at Europapark. The Void is a VR theme park in Pleasant Grove, Utah that has attractions where, by using VR, AR and customized mechanical rooms, an illusion of tangible reality is created by the use of multiple senses.

- Art show

Some museums have begun making some of their content virtual reality accessible including the British Museum and the Guggenheim. Some trails have been made to take viewers back to the scenes of thousands years ago by using VR technology.

- Music and concerts

VR has the possibility of changing how we view live music by allowing the audience to be right up front their band or to attend virtual concerts,VR can also transform music videos by making them more intense and powerful. Music visualization also has the potential to be changed by VR with multiple apps being created for the Oculus and the HTC Vive.

On May 3, 2016, Norwegian pop band a-ha gave a multimedia performance in collaboration with Void, a Norwegian computational design studio. The stereoscopic VR-experience was made available for Android users directly through a YouTube app and also made available for iPhone users and other platforms.

4.5 VR business model

Fig.2 shows the VR business model in China.

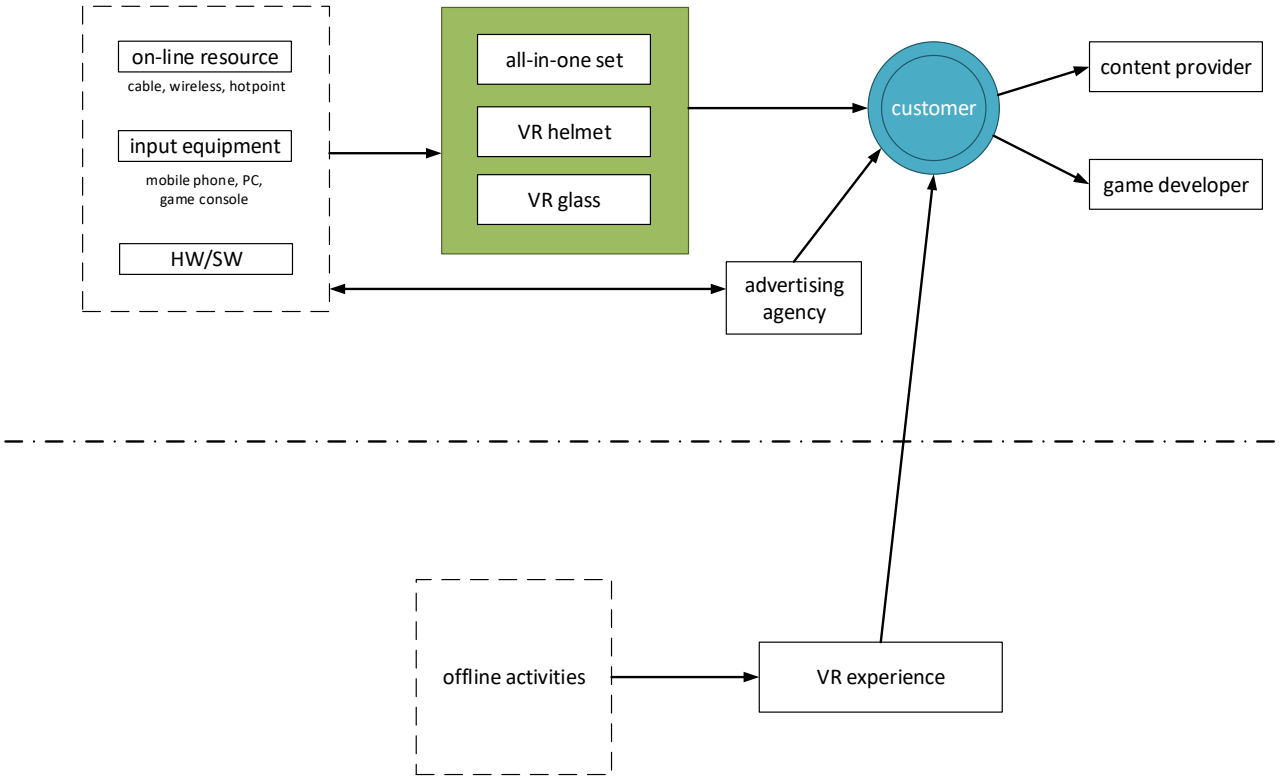

Figure 2 VR business mode

5 Technical Model of a VR equipment/system

VR is an integrated technology consists of 3D modeling, 3D display, sensor technology, real time graphic processing, etc. The VR equipment/system is designed to provide a accurate, real and interactive experience to the customer.

5.1 Overview

The relationship of different technical domain is shown in Fig. 3.

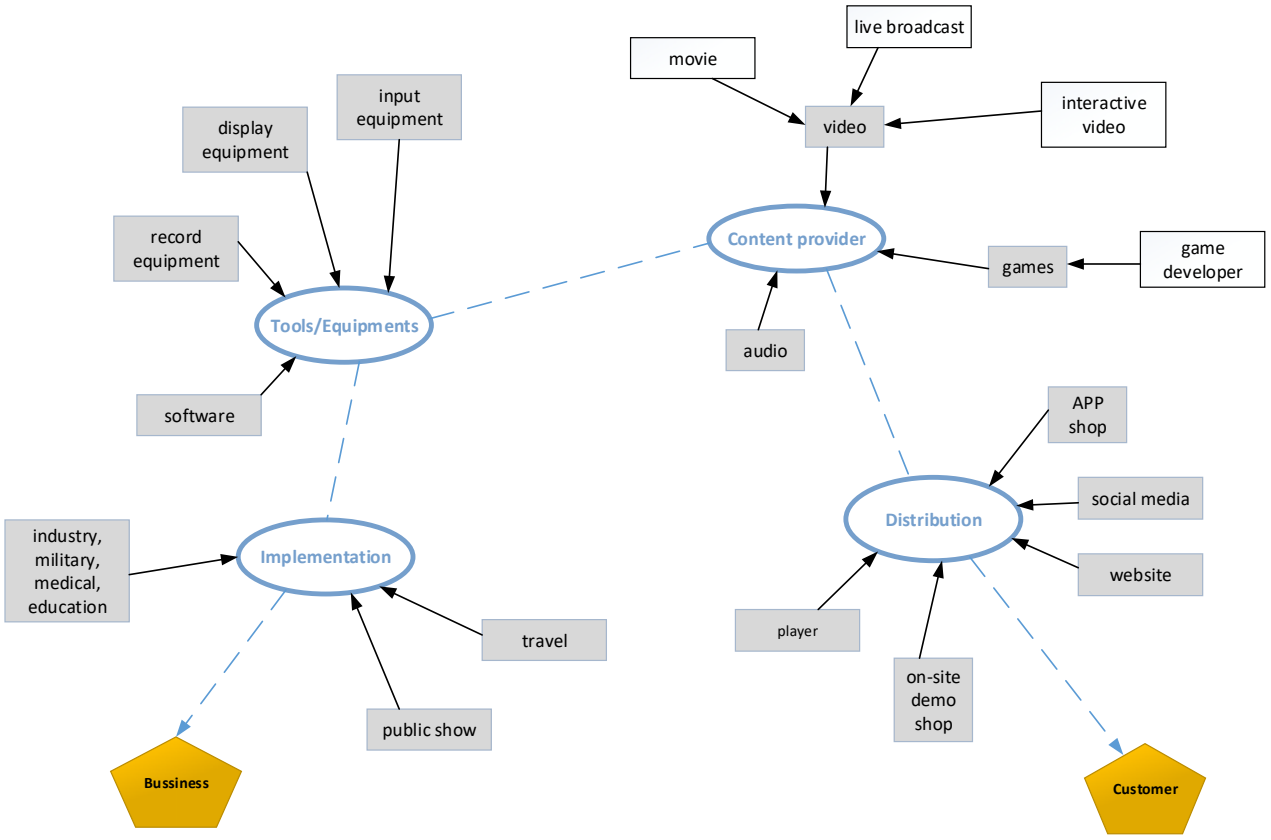

Figure 3 VR Technical Domain

5.2 List of key techniques

The above figure try to show all the related technical domains and their relationships in the VR technical eco environment. And following techniques are included in, as

- 3D modeling
Setting up a believable virtual environment is the key point of VR technology, by getting the 3D parameters of a real environment, the engineers can set up a virtual model of the real world, which is the basis for following processing.

- real-time 3D graphic processing & display
It is not difficult to form a 3D graphic using computer, it is difficult to do real-time 3D graphic generation and processing, without decrease image quality and loss of details.

- efficient interactive
It is quite important to find an efficient way to make the VR user to interact with the virtual world, and also have the response as in real world. Now a days, the input equipment will

be in the shape of headset display, data glove, date cloth, 3D location sensor, etc. In future, more needs for data glove/data cloth with new, low-price and better robostic character will arise.

- distributed virtual environment (DVE)
It is a quite important trend for using more DVE in medical, industrial, training and education, and started the use in co-design. The use of DVE in military training and medical education were reported recently, which were seemed to extend to other education area with the widely use of internet material in classrooms.

DVE also made it possible for the designers/engineers to work together, by using the same database and supported by standards/protocles, as if they were in the same office and worked on the same article. It is an virtual environment consisted by different area information, which needs more technical resources. And its use in space research area can save a great amount of money.

5.3 Technical bottleneck of VR

Although VR had a very charming future for widely usage and better performance, but there still some technical buckles on its way.

- limitations of HW/SW

It is a common situation for VR equipment with poor image quality and not easy-to-use. The requirement for processing large amount of data in a short time is still a heavy load to processor now a days. The data storage ability also meet the same challenge to record more for generate high quality 3D images.

Now a days, most of the VR equipment are expensive, and aimed to be used for specified area, as for military training, for education, there is still a long way for VR equipment come to house hold.

- complicated 3D modeling and time-consuming rendering

3D modeling and rendering are the two key steps for define an object in virtual environment, the more accurate the object is, the more complicated the 3D modeling will be. Now the rendering techniques had made great improvement in simulating the character of different covers, but accurate 3D modeling is still an unsolved problem, which needs the support of SW and improvement of computing ability.

- merging and processing of big data

The implementation of VR needs a very big data resource and high calculation speed. In order to maintain the needs of DVE, wide bandwidth and high transparent speed will be the must-have characters. A more efficient data depress method will be expected.

- lack of synthesis of video/audio/feel

To be real is the most important experience that a VR equipment/system should give to the viewers. But it is not enough to make viewer to feel “real” by display images, it should companies by 3D audio and accurate response of feels as vibrations or move of sight angles.

How to modeling more senses in a VR system is still a hard problem for experts, with the development of AI and electronics technology, there will be a hope to make the virtual world move to a more real one.

6 Recommendations

6.1 Expected standard framework for VR equipment/system

Based on the analysis of existing VR market and technology trend, the standards that expected to be developed for VR equipment/system will be shown in Figure X, the standards are not only the ones should be considered by TC100, but also include the ones that should be studied by other TC/SCs.

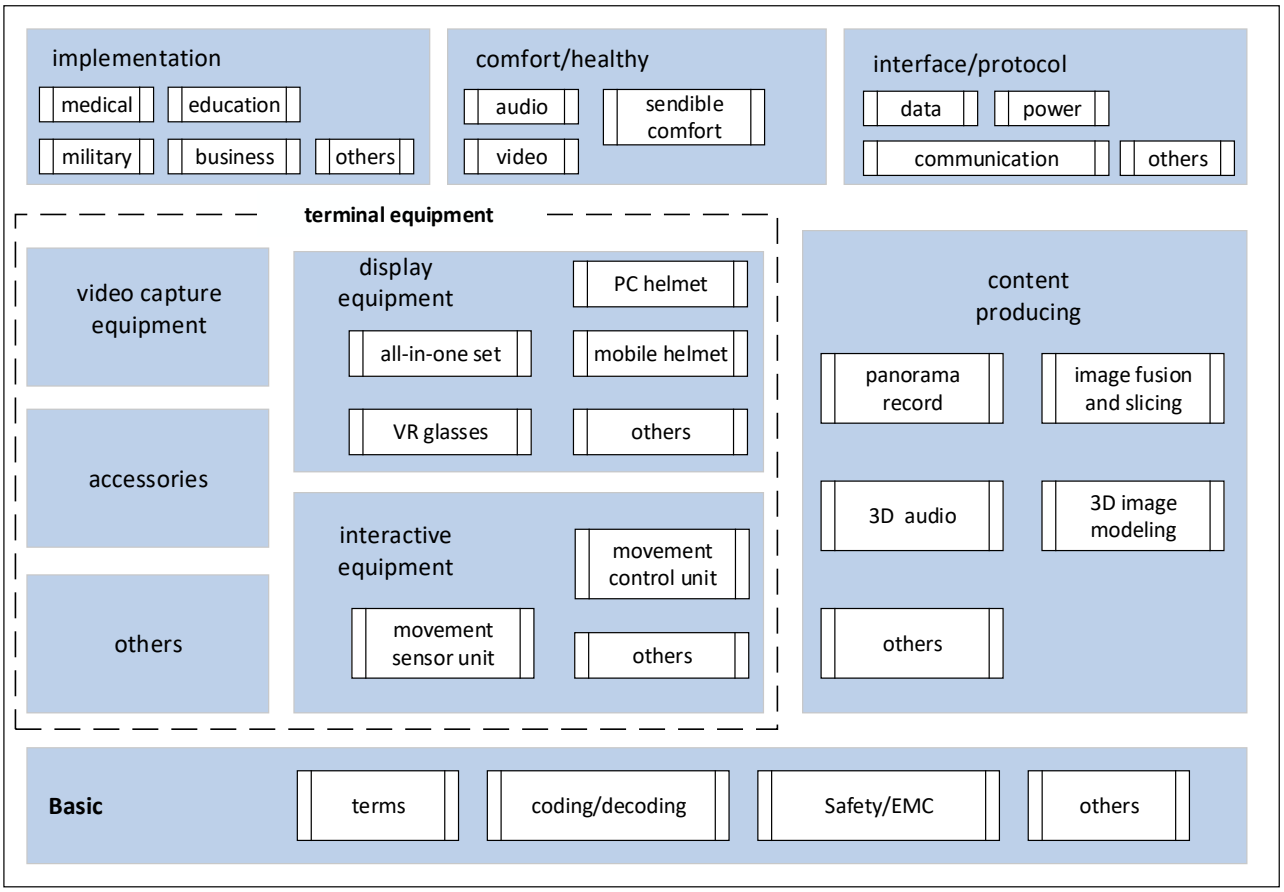

Figure 4 VR standard framework

6.2 IEC Domains Impacted
