# UNIT I

## INTRODUCTION & GRAPHICS FOR VR

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## CHAPTER 1

## INTRODUCTION

### Definition of X-R (AR, VR, MR)

**Reality:** Reality is a substance that actually exists in an external world. Reality is the way things actually are, not the way you might want them to be. Many TV shows claim to be reality, but they are really just pretend. The only actual reality is the life that happens every day.

**Examples:**

- Seasons change.
- Earth revolves around the sun.
- People need water and food.
- Rainbow is formed after the rain.

**Virtual Reality:**

- The word 'virtual' means something that is conceptual and does not exist physically and the word 'reality' means the state of being real. So, the term 'virtual reality' is itself conflicting. It means something that is almost real.
- Virtual Reality means we can experience things that never actually happen. It actually tricks our brain into thinking that we are in a different place using 3 of our senses-seeing, hearing, and touching. It creates a different world, and we feel we are a part of it, both physically and mentally.
- **Examples:**
  - We will probably never be on the top of Mount Everest or
  - Dive deep into the Mariana Trench or
  - Step on the Moon,
- But we might be able to do all these things without even stepping out of our homes, this is where Virtual Reality comes to the rescue.
- Virtual reality (VR), the use of computer modelling and simulation that enables a person to interact with an artificial three-dimensional (3-D) visual or other sensory environment. Virtual reality is the use of computer technology to create simulated environments.
- **Applications:**
  - **Entertainment**-Used for gaming, 3D cinema, and in theme parks.
  - **Medicine**-Used for surgery training, exposure therapy for people with phobia or anxiety disorder.
  - **Skill training**-Used for astronaut training, flight training, military training, etc.

- **Types of Virtual Reality:** There are three basic types of Virtual Reality

- **Non-immersive VR systems:** Users are aware of their surroundings and use a monitor to enter the 3-D world, for example, video games.
- **Semi-immersive VR systems:** Users usually have a large screen in front of them and input devices that they can use. Semi-immersive VR technology is used in flight simulation.
- **Fully-immersive VR systems:** These are VR systems that provide very realistic simulation. Users wear a headset and enter an alternate reality.

**Augmented Reality**

- The word 'augmented' means to add. It might not sound as exciting as VR but has impacted our lives deeply. Augmented reality uses different tools to make the real and existing environment better and provides an improved version of reality.
- Augmented Reality (AR) is a live, direct or indirect view of a physical, real-world environment whose elements are augmented (or supplemented) by computer-generated sensory input such as sound, video, graphics or GPS data.
- AR is a technology that overlays digital information onto the user's real-world environment. AR typically uses a smartphone or tablet camera to capture the real world and then superimposes digital objects or information onto the screen. AR is often used in retail, education, and advertising.

**Mixed Reality**

- Mixed Reality (MR), digital and real objects coexist and can interact with each other in real time.
- Mixed Reality (MR) is the merging of real and virtual worlds to produce new environments and visualizations where physical and digital objects co-exist and interact in real time.
- It means placing new imagery within a real space in such a way that the new imagery is able to interact, to an extent, with what is real in the physical world we know.
- **Examples**
  - Pokemon
  - GoVolvo Cars
  - Surgery Simulation
  - Education
- **Application**
  - Gaming
  - Architecture and engineering
  - Retail
  - Military

**Extended Reality**

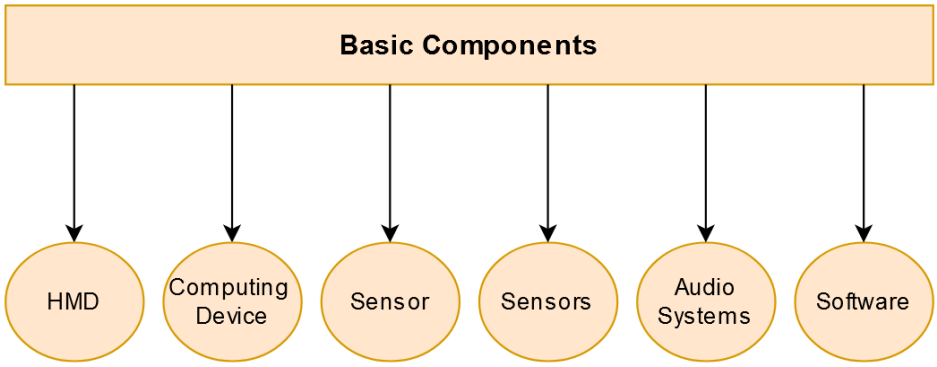
- Extended Reality refers to all real-and-virtual combined environments and human-machine interactions generated by computer technology and wearables.
- Extended Reality includes all its descriptive forms like the Augmented Reality (AR), Virtual Reality (VR), Mixed Reality (MR).
- XR can be defined as an umbrella, which brings all three Reality (AR, VR, MR) together under one term.
- Extended reality provides a wide variety and vast number of levels in the Virtuality of partially sensor inputs to Immersive Virtuality.

**Differentiation Between VR / AR**

| Sr. No. | Virtual Reality (VR) | Augmented Reality (AR) |
|---|---|---|
| 1 | Virtual Reality creates a fully immersive digital environment or experience that simulates the real world or imaginary world. | Augmented Reality overlays digital information into the real world. |
| 2 | It generally requires a headset or a similar kind of device to immerse the user into the digital world. | It can be accomplished through smartphones or tablets with the help of AR apps. |
| 3 | The user is isolated from the real world while in VR. | The user is aware of the real world while experiencing AR. |
| 4 | It requires powerful hardware and software to create a realistic experience. | It requires relatively simple technology for the creation. |
| **5** | **Examples**: PlayStation VR, Samsung Gear VR, and HTC Vive. | **Examples:** Pokemon GO, Google Maps AR, and IKEA App. |

| Sr. No. | Features | Mixed Reality (MR) | Augmented Reality (AR) |
|---|---|---|---|
| 1 | Combination | Combines the real with the virtual worlds | Overlays virtual elements on real-world |
| 2 | Interaction | Enables real-time communication between the virtual and physical worlds | Facilitates interaction between virtual and real-world aspects |
| 3 | Spatial Awareness | Uses sensors and cameras to keep track of the user and the surrounding environment | Uses a camera and GPS to monitor the person and their surroundings |
| 4 | Realistic Visualization | Utilizes cutting-edge graphics and monitors with high resolution to produce lifelike virtual things | Basic 2D or 3D graphics are superimposed on the actual world |
| 5 | Immersion | Creates a fully immersive experience by blending the virtual and real world | Creates a partially immersive experience by overlaying virtual elements on real world |

**Basic Components of VR**




1. **Computing Device:**
    a. It is a strong, powerful machine that processes and creates the 3-dimensional world.
    b. All other input devices pass their data onto it, it tracks the user movement and renders all the graphics.
    c. Computing devices should have a large amount of RAM, a good GPU, a powerful CPU, and a sufficient storage device.
2. **HMDs:**
    a. It is a head-mounted display that consists of two screens that display the virtual world in front of the users.
    b. They have motion sensors that detect the orientation and position of your head and adjust the picture accordingly.
    c. It also usually has built-in headphones or external audio connectors to output sound.
    d. Moreover, they have a blackout blindfold to ensure the users are fully disconnected from the outside world.
3. **Sensors:**
    a. Sensors are mostly incorporated into the headset of VR. They track users' poses and their head position, detect movement and rotation, and then pass all this data to the VR processor/computing device.
    b. Because of these sensors, the user can interact with the virtual environment. VR depends upon several sensors, including accelerometers, gyroscopes, magnetometers, and 6DoF.
4. **Input Devices:**
    a. Input devices are used by users in the VR system to interact with the virtual world in front of them.
    b. These devices might be a tool or a weapon in their artificial world.
    c. The input devices include mice, controllers, joysticks, gloves with sensors, and body tracking systems.

5. **Audio System:**
    a. Audio systems have a particularly important job in VR, ensuring a great VR experience in which users' brain is forced to think like they are in that artificial world.
    b. They are mostly integrated inside the HMD. VR provides spatial audio, so the users feel how real the virtual world is.
6. **Software:**
    a. Software is a crucial part of VR systems. The software is an application designed that runs on VR hardware and creates an artificial world.
    b. There are several different types of software based on what users need. For example, games, simulations, medical ecosystems, etc.

**Applications of Virtual Reality In Various Industries**

1. **Education & Training**
    - Virtual reality can create a world around the student that **feels real and immersive.**
    - Another great benefit of virtual reality in the education and training sectors is the **ability to gamify the concepts**. The gamification of concepts can completely transform the way a student learns.
    - Implementing virtual reality in classrooms can allow students **to see the concepts unfold in front of their eyes**. They can interact with the various aspects of the virtual world, helping them learn and understand something beyond the written word.
    - A student can perform experiments, learn core reaction concepts, and balance them in vivid detail.
2. **Healthcare**
    - Healthcare professionals use virtual reality during their **training for surgeries** when cadavers are limited or not available.
      (****A cadaver or corpse is a dead human body. Cadavers are used by medical students, physicians and other scientists to study anatomy, identify disease sites, determine causes of death, and provide tissue to repair a defect in a living human being.********)
    - For instance, an **orthopaedic surgeon** can practice complicated surgery in a virtual setting. The virtual reality headset allows surgeons to practice surgeries on virtual bodies, helping them improve their skills.
    - VR can also be of great help in the **treatment of mental health issues**. This new technology has been extensively used in treating mental disorders such as PTSD and anxiety. Another great example of VR implementation in healthcare is the EaseVRx for treating pain. The system uses cognitive and behavioral therapy, attention-shifting, and introspective awareness to reduce pain perception.

3. **Retail Industry**
    - Shopping online does not have the same experience as shopping in a store. All this is set to change as we move into the future of VR technology.
    - One way shopping online can drastically change using VR is by using **features like body scanning technology**.
    - Imagine if you could **try out the clothes** you like online before purchasing them. With virtual reality equipment, it is becoming possible.
    - With virtual reality and augmented reality, the customers will know exactly what they are buying and how it will look on them. Various online retailers are trying to implement VR technology.
4. **Tourism**
    - The tourism industry was the worst hit during the recent pandemic and lockdowns. Traveling in person was out of the question with people confined to their homes.
    - Imagine **exploring the streets of Rome from** the comfort of **your home** in New York! With the virtual world, it is quite possible. In the post-covid world, VR tech can help you experience a tour virtually before you decide to buy it.
    - Thomas Cook, one of the biggest tourism companies in the world, launched their "try before you fly" VR experience in 2015.
5. **Architecture & Interior Design**
    - VR can help architects see how the building will look and feel. You can navigate through the virtual building long before it is made.
    - Although architects have been using 3D models, VR technology opens a new world to them. The immersive experience of VR technology can help architects perfect your homes before they are constructed.
    - Interior designers can also take benefit of VR to plan out the designs and layouts of rooms.
6. **Sports & Entertainment**
    - This technology can be employed by coaches as well as players for training effectively across various sports, with them being able to view as well as experience particular scenarios repeatedly and enhancing their performance every time.
    - VR is also adopted to serve as a training aid for assisting in assessing athletic performance and examining techniques.
    - It's also been known to enhance the cognitive capabilities of athletes while injured by allowing them to virtually experience gameplay situations.
    - Various broadcasters have begun streaming live games through VR and are arranging to sell virtual tickets for live sports events which will allow people situated anywhere in the world to be a part of any sports event.

7. **Automative & Manufacturing**
    - In the automotive and manufacturing industry, VR technology allows engineers to experiment with the look and build of a new car design before commissioning a prototype.
    - Various well-known brands like Jaguar, BMW, and Ford have been using VR in their design process to fine-tune their prototypes.

**Benefits of VR**

1. **Safe, Realistic and Controlled Environment to Learn**
    - VR provides a safe and realistic way to train, without the risk of injury or costly damage to expensive equipment. There are some immediate use cases which highlight this:
        - Doctors can **practice difficult surgeries** they might not have performed before
        - Workers can learn how to **operate a crane** without needing to actually be inside one
        - **Firefighters can simulate dealing with fires** without putting their lives at risk
        - Employees can learn how to **deal with active shooters** or robbery
        - Staff can **practice working with a new food production machine** without the possibility of destroying the equipment

    - Through immersive VR, trainees get to **safely experience situations** that may normally be unsafe.
    - And perhaps most importantly, they can practice in these virtual situations **as often as needed** to feel **prepared and confident**.
    - Using interactive training techniques that manuals and videos can't provide, employees can **experience**, **make mistakes and learn through repetition**, which is often impossible in the real-world when it puts the organisation at risk.


A demo by Flaim System showing how VR can be using to train firefighters in VR.

2. **Perform Training Remotely: Save Time, Money and The Environment**
    - Traditional instructor-led training often requires employees to gather at a designated location, resulting in employees having to commute. However, immersive learning through VR eliminates these drawbacks by **allowing**

**employees to undergo training within their office or** even from the comfort of their **homes,** without the need for travel.

- By embracing VR for training, organizations can **save significant time and costs** associated with employee travel. Employees no longer have to allocate time for commuting or being away from the office, enabling them to dedicate more hours to productive work.
- Trainees can easily download and access training materials from anywhere, eliminating geographical barriers and enabling seamless participation in training programs.
- By eliminating the need for travel, organizations can reduce their carbon footprint and contribute to sustainability efforts.

3. **Improves Retention and Recall**
   - Higher engagement rates typically lead to higher retention rates and recall. **memory retention** after a VR experience **is higher** than after viewing video or text-based learning materials.
   - An example highlighting this gave half the participants a 360-degree VR video of a motorcycle ride to watch, while the other half watched a regular 2D video. A memory test 48 hours later showed that the VR group performed twice as well as the video group in the memory recollection test.
4. **Repeatable and Controlled Exposure to Stressful Situations**
   - Another benefit is that our **emotional and physiological response to stimuli** in VR **is close to what we would expect** in real life situations.
   - During a VR experience, patients can safely be exposed to stressful stimuli.
   - Over time, this experience reduces the stress or fear response of the participant to that stimulus.
   - VR experiences are **easily repeatable**, allowing subjects to be exposed to varying levels of intensity in the experience.
   - The subject can therefore gradually become accustomed (become used to) to the stronger stimuli. Any stressful situation can be turned into a safe VR experience, such as dealing with an angry customer and putting out a fire.
5. **Highly Engaging Training at Scale**
   - VR provides a **way to train large numbers of employees** in an effective way.
   - Previously, organisation had to choose between less effective but scalable solutions (i.e. videos and online courses) and effective but expensive solutions (i.e. instructor-led and on-the-job training).
   - Moreover, the integration of data analytics within VR training provides valuable insights for Learning and Development (L&D) teams.
   - It allows them to track and measure individual employee progress, completion rates, and performance during training sessions.
   - Additionally, organizations can assess the return on investment (ROI) of their VR training initiatives.

6. **Isolation from Distractions**
    - Keeping people motivated during both online and in-person training sessions can be a challenge. The constant temptation of checking your mobile phone and other distractions cause learners to lose focus.
    - When employees put on a VR headset, the experience captures the learner's full attention through both visual and audio stimuli – users are fully immersed in the virtual environment where they can learn distraction free.
7. **Improve Skills Faster Through Experiential Learning**
    - Virtual reality speeds the development expertise through repeated experiential learning that broadly engages multiple learning systems in the brain in synchrony and is scalable.
    - Learning by doing has long been established as one of the most effective ways to improve a skill.
    - When you perform the task over and over again in a realistic setting, you improve that skill much faster than if you just read or watched a video about it.

Practice various soft skills in VR with the VirtualSpeech app.

8. **Skills Assessment and Data-Driven Insights**
    - How do you assess an employee's role for a new position in the organisation? How do you evaluate performance based on quantifiable data?
    - Humans introduce a huge amount of variation during assessment of an employees or candidates' performance. They can introduce bias without knowing it, questions can be interpreted differently depending on the person or there might not be sufficient data to properly assess the person. In addition, people might lie about their qualifications and experience, adding to additional variation.
    - VR and immersive learning exercises can be used to assess whether employees are best suited to a given role or set of roles, as well as to better understand how candidates and managers would behave in real-world scenarios, if hired.


An example of speech analysis scores in the VirtualSpeech app.

**Key Elements of Virtual Reality Experience**

1. **Immersion:**
    a. Immersiveness is one of the most critical elements of VR systems. It provides the user with a sense of being physically present in a non-physical world.
    b. It envelopes a sense of presence, which makes the brain truly believe that they are somewhere that they are not. The users are placed in a virtual space, cut from the real world on a sensory level.
    c. VR headsets allow this by occupying their whole field of vision, while headphones achieve the same results with sounds, thus fully immersing the users in another world.
    d. This is achieved by the VR device enveloping your field of vision entirely and using 3D images and stereo sound.

    **Mental Immersion**

    Mental Immersion is a deep mental state of engagement, with the suspension of disbelief that one is in a virtual environment.

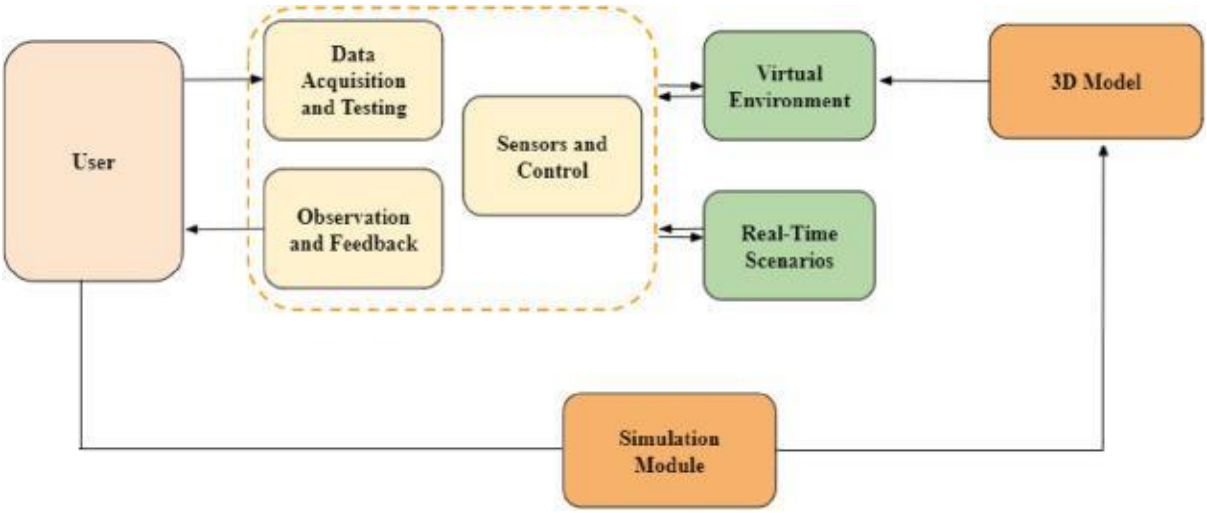
    **Physical immersion** is where one exhibits physical engagement in a virtual environment, with the suspension of disbelief that one is in a virtual environment.
2. **Interactivity:** Interactivity in VR systems invites active user participation. The environment responds in real-time to your movements, and sometimes actions, providing a deeply engaging experience.
3. **Consistency:** Consistency is necessary for maintaining the illusion of reality within the VR system. It should consistently provide feedback that aligns with your actions and the virtual environment, ensuring the user experience is as seamless and real as possible.
4. **Sensory Feedback:**
    a. Virtual reality requires all senses to be activated. The main ones include vision, hearing and touch. Stimulating all these senses provides sensory feedback.
    b. This is done through the use of integrated hardware and software known as inputs.

c. Examples of this hardware and inputs includes head-mounted displays (HMD).
d. Any VR developer understands that the more human senses a virtual environment involves, the more realistic it is.
e. Besides activating visual and aural sensory, virtual reality should provide users with haptic feedback to properly simulate a real world.

**Virtual Reality System – Overview**

**HCI (Human-Computer Interaction) Based VR**

- The main objective of VR systems in HCI is to design a beneficial platform that is feasible and reliable for establishing an effective interaction Techniques such as hand gesture-based recognition systems and action-based interactive systems play a vital role and are mainly employed in different engineering, empirical, and education-based applications.
- The capability of providing a comprehensive and clear picture of a concept is obtained by representing the object in a 3D spatial manner using computing devices.
- The system has a head-mounted display, and information flows in these systems, which makes the user an integral part of the interfacing system.
- Following figure illustrates different modules involved in the design of an HCI-based VR system.




HCI Based Virtual Reality System

- An HCI-based VR system is a closed-loop system that **artificially creates communication between the virtual environment and real-time scenarios**.
- A VR system comprises a **data acquisition and testing** module that **takes user instructions as input.**
- **Sensors** act as an **interacting system** between **user and interface**. It **collects and tracks** different **interaction modes** such as **gesture**, **voice**, or **touch**.
- The **control unit interacts with** the **virtual environment** and **provides feedback to users with virtual images being displayed**.

- The **user** can **interact with** the **virtual environment** usually represented in the **form of a 3D model**.
- The innovation is that each user's **interaction** with the virtual environment is **quantitatively and qualitatively analysed** using the simulation module for simple and complex tasks without the need of intermediate devices.
- Real-time experimental analysis is conducted to validate the efficacy of systems.
- Empirical research must be conducted such that hypothetical information is nearly identical to the real design.
- Implementation aspects must incorporate various technically verified hypotheses that include integrated conceptual models, facts, and techniques that act as connecting medium between the constructive solutions and theoretical aspects.
- Interaction through multiple platforms provides a broad scope and great impact on user experience in VR.
- Design of a multiuser VR system aids the manufacturing process in product structure and layout planning.
- The system supports globally distributed manufacturing companies in the design and review process through a collaborative platform.


**Virtual Environment**

**What is Virtual Environment**

- A VE is an immersive synthetic environment that allows the operator to understand the schematics of the process and of the plant, not only at the representation level.
- It also allows absorbing the corresponding feelings and emotions, i.e. those felt in reality. The operator, during the training session, experiences his/her physical presence within the rendered environment.
- Immersed in the VE, s/he is free to move around the virtual equipment without the risk of getting injured, being exposed to heat radiation or affected by real accident events, with the advantage of experiencing the same emotions and feelings s/he would experience in reality, e.g., the same anxiety, fears, and concerns.

**VE Challenges**

- Virtual environments come with special challenges. Some of the challenges include data centers, security considerations, storage virtualization, malware, and the drawbacks associated with the use of virtual environments.
- Such challenges include storage and storage considerations such as DAS, NAS, and SAN technologies and VMFS.

**VE System Control**

- Virtual environments typically involve many **settings and require to initiate commands**, such as loading a medical data set in a medical application.
- In desktop systems, toolbars or pull-down menus are provided to **select options and adjust parameters.** Similar facilities are needed in VR.
- In VR, however, it is challenging to ensure that these options are visible and recognizable for the current user. Thus, to display these options at fixed positions is often not recommended, the system control options may be occluded (Stop or close up) or just too small to be recognized.
- As an alternative, slightly related to a pop-up menu, the options may be displayed at a position close to the current position of a controller
- With this option, the menu appears relative to one hand of the user. The second hand may be employed to trigger a selection, e.g., based on shooting a ray
- System control involves the adjustment of numerical values (slider functionality) and the selection of options (radio button and check box functionality) in addition to the selection of menu entries.
- The selection of an appropriate font and font size and the placement such that text appears without or with low distortion are essential aspects for the usability of system control options in immersive VR.

**Interfaces to the Virtual World-Input & output- Visual**

To interact with objects of the virtual world, one must be able to perceive and handle these objects. Thus, the VRI can be classified according to three large families: Sensorial Interfaces, Motor Skills Interfaces, and Sensorimotor Interfaces.

1. **Sensorial Interfaces**

   The role of the sensorial interfaces is to make it possible for the user to perceive objects of the virtual world. And as in the real world, the more the number of senses stimulated in the virtual world is high, the more the feeling of immersion of the user is great. Although we are critical of the results, it is intriguing to know the order of magnitude of the mobilization capacity of each sense: the sight (70%), hearing (20%), smell (5%), touch (4%), and taste (1%).

   **a) Visual Interfaces:**

   - As the sight is the sensory channel that brings the most information to the human. It is essential to create visual immersion and thus allow the users to see objects of the virtual world.

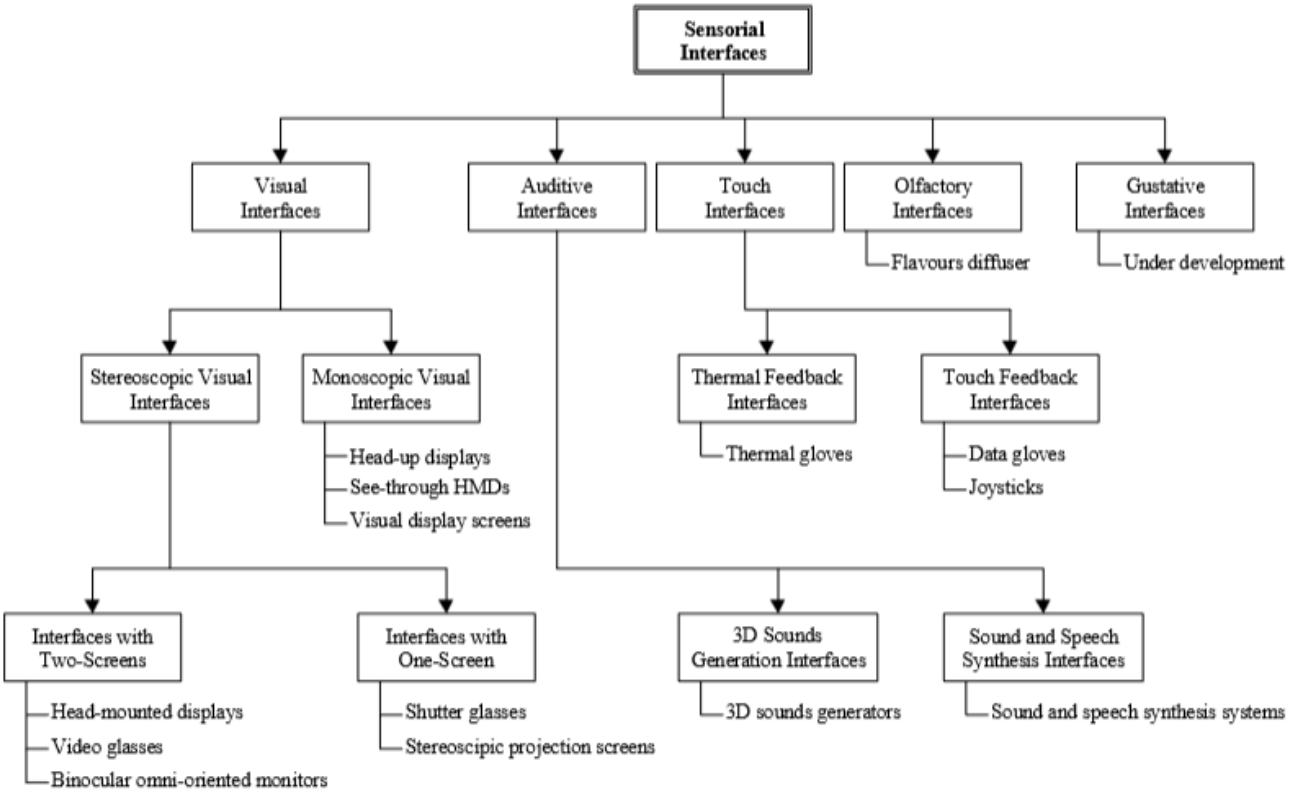
- **Challenges:** i) To producing good quality 3D images. ii) To show a different image to each eye and allow the users to benefit from the stereoscopic vision.
- Visual interfaces were **classified according to the technique used to separate the images intended for each eye.**
- Thus, the visual interfaces are divided into two classes:
  **Stereoscopic visual interfaces:** These are divided into two types of interfaces: (1) Interfaces with **two screens (one per eye)**. E.g. Head-mounted displays, video glasses, and binocular omni-oriented monitors; (2) Interfaces with **only one screen (for the two eyes)**. E.g. Shutter glasses and stereoscopic projection screens. The images are then separate at the screen level or by the glasses.
  **Monoscopic visual interfaces.** The monoscopic visual interfaces take shape through head-up displays, see-through HMDs and visual display screens

**b) Auditive Interfaces.** To increase the feeling of immersion and even impact the visual perception of the virtual world, the hearing sense can be exploited. The sounds generated by the computer must be 3D and come from the elements present in the virtual world. The auditive interfaces were **classified into two categories**: (1) **3D sounds generation interfaces** (2) **Sound and speech synthesis interfaces.**

**c) Touch Interfaces.** In several domains such as teleoperation, telemedicine and telerobotics, the sense of touch is necessary to better appreciate the virtual world. Moreover, the hand has a high density of tactile sensors that make it a good candidate for immersion, and it is naturally used for the handling task. The touch interfaces were classified into two categories:
**(1) Thermal feedback interfaces (2) Touch feedback interfaces.**

**d) Olfactory Interfaces:** The synthesis of simple odours (e.g., coffee, burned rubber, flower, moisture, et c.) is possible with the **mixture of odorous molecules** (not more than two at the same time if one wants to recognise the final odour) and through the **use of a flavour diffuser**. The absence of basic odorous molecules, by analogy with the basic colours in painting, makes impossible for the moment the synthesis of odours.

**e) Gustative interfaces:** Gustative Interfaces do not exist yet. Various applications are possible, one can think of rooms for **virtual tasting of foods**. It would be possible to taste wines, coffees, etc. Simply through gustatory devices, as we smell odours through odorous strips in perfumeries.




**2. Motor Skills Interfaces**

The role of the motor skills interfaces is to allow the user to act on the objects of the virtual world. To do so, one must provide the computer with information on the user's gestures and speech that concern the objects of the virtual world so that it can react to them in a suitable way.

**a) Position and Orientation Location Interfaces:**

3D position sensors, commonly called trackers, allow the user to know at any time the position and orientation of his/her members (head, wrist) or of an object (effector, stylet) in space. The trackers use either one of the following technologies: electromagnetic, electric, acoustic, optical, mechanical, gyroscopic or hybrid.

**b) Finger Movement Detection Interfaces:**

These interfaces take shape through **data gloves** which detect some or the totality of the relative finger movements in relation to the wrist. The gloves are based on either one of the following technologies: Optical fibres, plates, Hall effect or pneumatic.

**c) Walking analysis Interfaces:**

Soles & force feedback platforms can be used to analyse the walking of a person. Walking analysis interfaces allow one to collect information on the walking of a person, which includes the pace length, the walking speed, the body movement & balance, etc.

**d) Motion Capture Interfaces:**

These interfaces can be divided into two categories: 2D- vs 3D- restitution motion capture interfaces. Their role is to collect data on body movements. (1) 2D include an image analysis system, allow to analyse the video images of the tracked person. (2) 3D allow to build a 3D model of a body in movement, and to benefit from the advantages of natural movements by a human in real environment.

**e) Command Interfaces:**

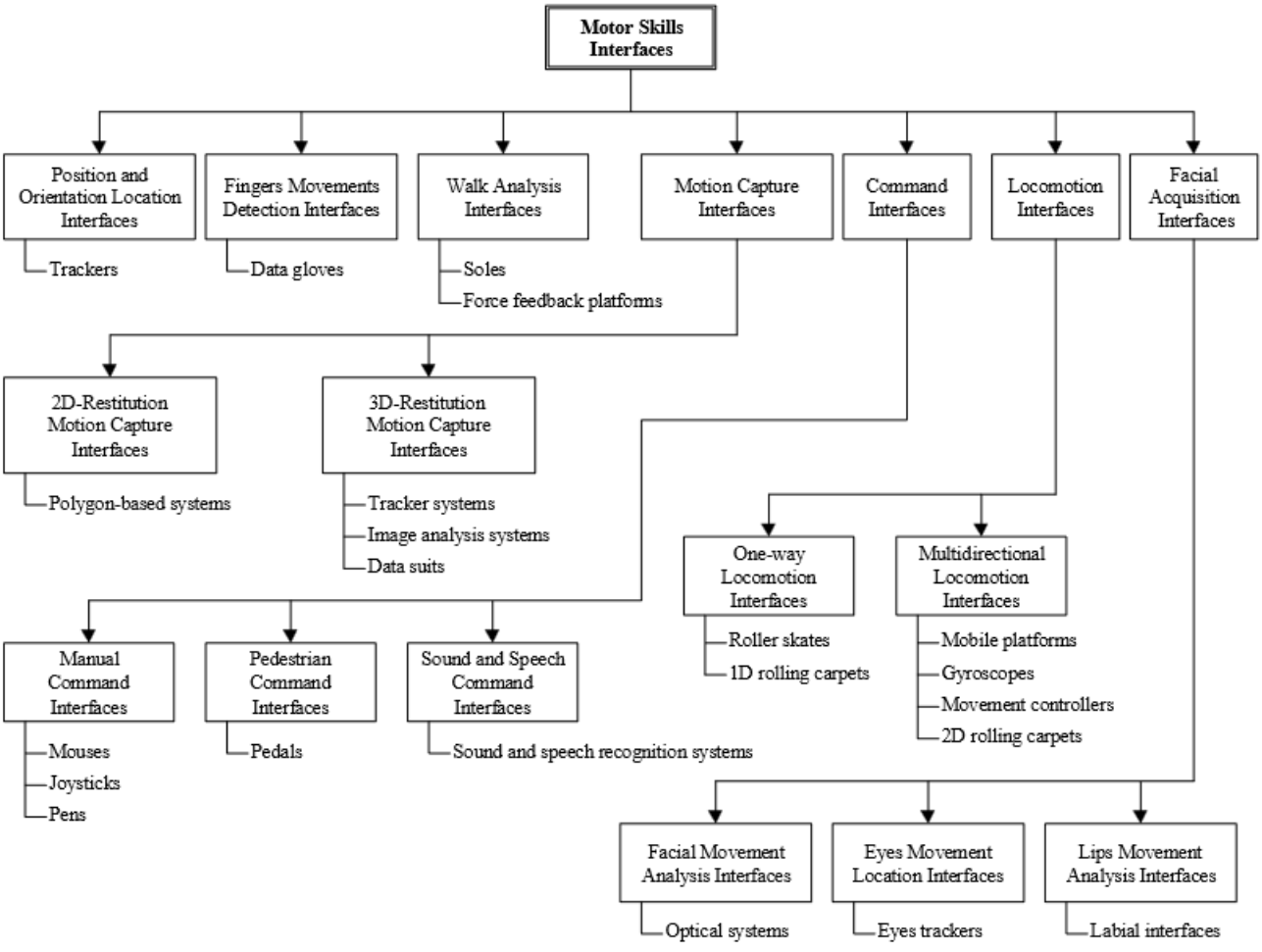
These are used to send orders to the virtual world. It is not rare to meet traditional control devices in virtual reality. Three categories are (1) Manual (2) Pedestrian (3) Sound & Speech.

**f) Locomotion Interfaces**

The role of these interfaces to have the user think that he/she is moving into a virtual world. They can be divided into (1) One-way Locomotion Interfaces (2) Multidimensional Locomotion Interfaces.

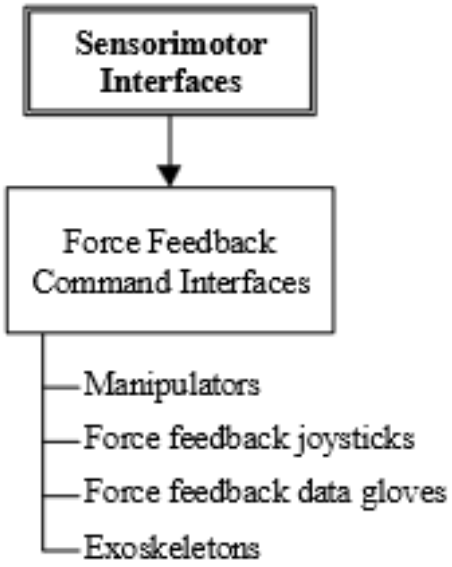
**g) Facial Acquisition Interfaces:**

It allows the computer to collect the facial movements of the user with various expressions: Joy, sadness, fear, anger, surprise, dislike, daydream etc. in order to produce these movements on synthesis face. These interfaces can be divided into (1) Facial movement analysis interface (2) Eye moment location interface (3) lips movement analysis interface.



### 3. Sensorimotor Interfaces

- The role of the sensorimotor interfaces is to transmit the motor responses of the user to the computer, and as a reaction, sensory stimuli are sent by the computer to the user.
- Only one subcategory of sensorimotor interfaces that include these two functions could be identified.
- These interfaces have some resemblance with the simulators of movements that transmit changes of orientation and accelerations to the users present in the simulator.
- They allow one to materialise the objects present in the virtual world: they apply to the part of the body in contact with the virtual object, the reciprocal forces that the user would exert on the real object.
- The forces to be simulated can be exerted by a liquid or a solid.
- The problem with the force feedback command interfaces, which include manipulators, force feedback joysticks, force feedback data gloves, exoskeletons, etc. is that they must be built on a solid frame and they cause some nuisance to the user classification.




- The goal was to help the VR community to get a better understanding of the domain by providing it with a solid and unified framework about the interfaces.
- The next step will consist to document each VR interface and to design a computer-aided decision-making system for helping designers and developers to choose and combine VRI in relation with the tasks, the context, and the users' requirements.

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