5

Building a VR system

Motion capture and sensory output

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IMT Atlantique

COURSE NOTES

Building a VR system means connecting measurement, simulation and sensory output in real time. Tracking provides information about the user, software updates the virtual world, and interfaces generate the feedback. Accuracy, timing and calibration determine whether these components form a coherent loop.

Course outline

Motion capture

5.1

Sensory output

5.2

COURSE NOTES

Building a VR system means connecting measurement, simulation and sensory output in real time. Tracking provides information about the user, software updates the virtual world, and interfaces generate the feedback. Accuracy, timing and calibration determine whether these components form a coherent loop.

The course covers motion capture, followed by output devices organised by sensory stimulation type.

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Online slide ↗

Part 1 of 2

5.1
Motion capture

COURSE NOTES

A rigid pose has three translational and three rotational degrees of freedom. A three-degree-of-freedom orientation tracker cannot determine arbitrary head translation. Coordinate conventions differ between systems, so axis names and handedness must be explicit. Pose is an estimate with uncertainty, not an exact measurement.

Slide 4 / 56

Online slide ↗

5.1 Motion capture

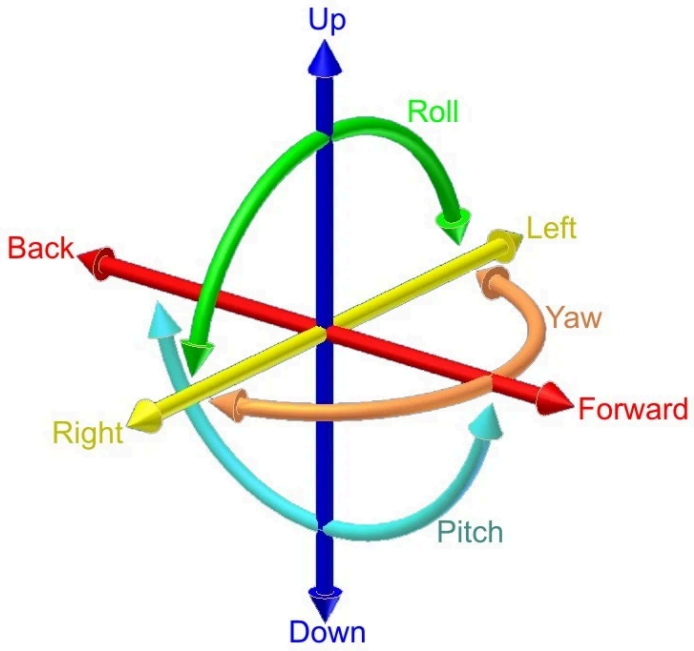
Six degrees of freedom

Translation

Left/right, up/down, forward/back

Rotation

Yaw, pitch and roll



Position and orientation axes

COURSE NOTES

A rigid pose has three translational and three rotational degrees of freedom. A three-degree-of-freedom orientation tracker cannot determine arbitrary head translation. Coordinate conventions differ between systems, so axis names and handedness must be explicit. Pose is an estimate with uncertainty, not an exact measurement.

Mechanical tracking

Telepresence Mobile Robot (1991)



Telepresence Mobile Robot, 1991.

Watch the video ↗

SPIDAR-8



Two-Handed Multi-Fingers Haptic Interface Device: SPIDAR-8

Watch the video ↗

COURSE NOTES

Mechanical tracking physically connects the tracked object to an articulated structure. Measured joint angles allow position and orientation to be calculated from the mechanism’s geometry. The linkage imposes workspace and movement constraints.

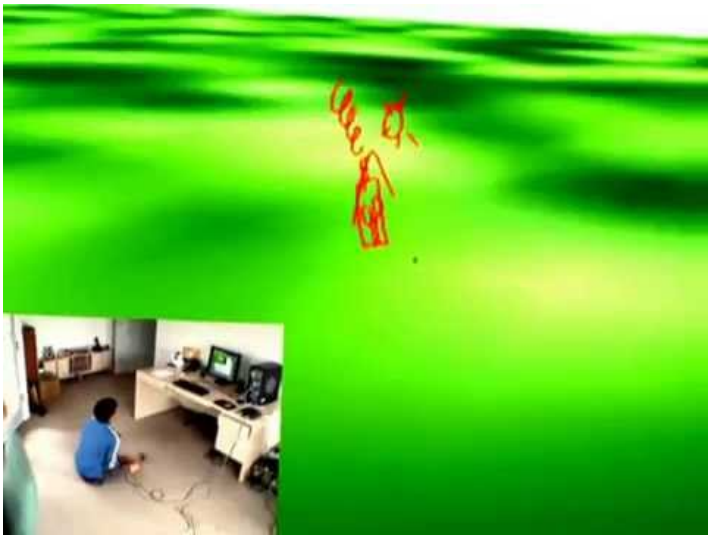
Telepresence Mobile Robot, 1991. — Scott Fisher. https://www.youtube.com/watch?v=QpTQTu7A6SI

Two-Handed Multi-Fingers Haptic Interface Device: SPIDAR-8 — Tommy. https://www.youtube.com/watch?v=m-DS1U_INpQ

Electromagnetic tracking



Polhemus FASTRAK



Virtual Reality--3D Drawing Application-Polhemus Motion Tracking Technology

Watch the video ↗

COURSE NOTES

Electromagnetic tracking estimates sensor pose from the field generated by a transmitter. It requires no direct line of sight between source and sensor. Conductive and ferromagnetic materials can distort the field and affect measurements. Range depends on the system.

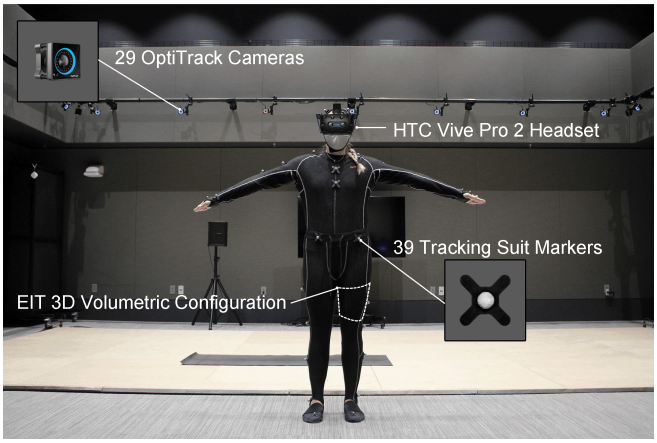
The FASTRAK photograph shows the processing unit, transmitter and a small wired sensor.

Virtual Reality--3D Drawing Application-Polhemus Motion Tracking Technology — Polhemus. https://www.youtube.com/watch?v=7DlEfd0VH_o

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5.1 Motion capture

Current tracking technologies



Optical: OptiTrack (MuscleRehab)



Inertial: Xsens Link suit

COURSE NOTES

Optical tracking uses visible or infrared observations. Depending on the device, it tracks known markers, environmental features or light signals. Cameras may be external or onboard. The next slide distinguishes inside-out and outside-in arrangements.

An inertial measurement unit (IMU) typically contains gyroscopes and accelerometers. Gyroscopes measure angular velocity. Accelerometers measure specific force, which includes the effect of gravity depending on sensor orientation. Estimating displacement requires accounting for this component and integrating measurements. Bias and error accumulate: an IMU alone does not provide drift-free absolute position.

Inertial measurements enable rapid updates between optical observations. Optical observations provide constraints that limit drift. Sensor fusion is discussed after the tracking arrangements.

Documented example: Microsoft describes headset tracking that fuses camera observations with high-rate IMU measurements. https://learn.microsoft.com/en-us/windows/mixed-reality/enthusiast-guide/tracking-system

Left, the MuscleRehab setup uses OptiTrack cameras and body-worn markers for optical motion capture. Image annotations identify cameras and markers. The project’s EIT muscle measurements are separate from optical tracking. Right, the Xsens Link suit illustrates inertial

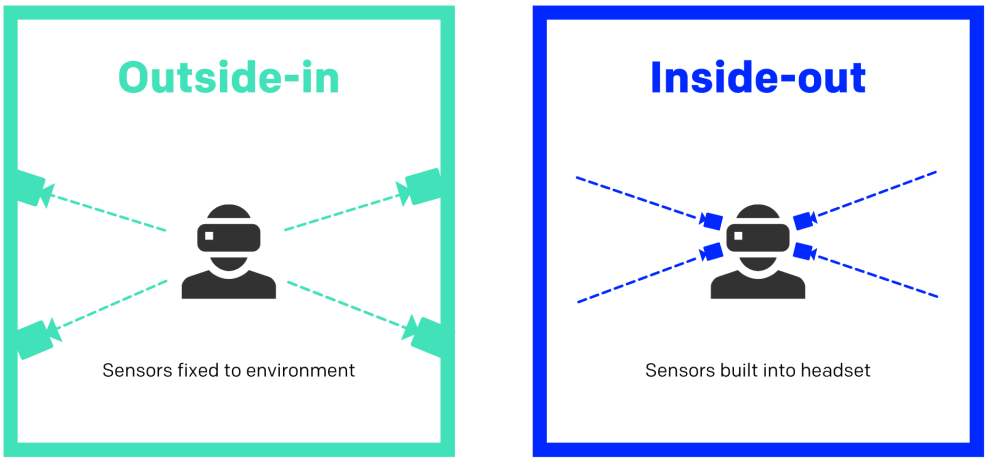
tracking using body-worn sensors. Photo sources: MIT CSAIL, https://hcie.csail.mit.edu/research/musclerehab/musclerehab.html and Xsens, https://www.xsens.com/motion-capture/xsens-link-specifications

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5.1 Motion capture

Inside-out and outside-in: principle



Outside-in: external cameras. Inside-out: onboard cameras.

COURSE NOTES

The diagram compares camera placement: in the environment for outside-in tracking, on the tracked device for inside-out tracking. Dotted lines indicate observation directions. The next slide illustrates both arrangements with a Quest and a Rift CV1 camera.

Original diagram: https://thewild.com/blog/architect-getting-started-with-vr

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Slide 9 / 56 Online slide ↗

5.1 Motion capture

Inside-out and outside-in tracking

Arrangement	Observation	Typical limitation
Inside-out	Sensors carried by the tracked device	Needs usable environmental observations
Outside-in	External sensors observe tracked objects	Needs coverage and line of sight



Inside-out: cameras on the headset (Quest)



Outside-in: camera in the room (Rift CV1)

COURSE NOTES

These terms concern the arrangement of sensing. Inside-out commonly uses cameras and inertial sensors on the headset. Outside-in can use external cameras or other infrastructure. Hybrid arrangements exist. Neither term alone specifies accuracy, latency or what happens during an occlusion.

Photos: left, the Quest's four onboard cameras are circled in purple (vrCAVE Operation Guide). Right, an external Rift CV1 camera observes infrared markers on the headset and controllers (photo: Evan-Amos, public domain).

Sensor fusion

Fast local changes

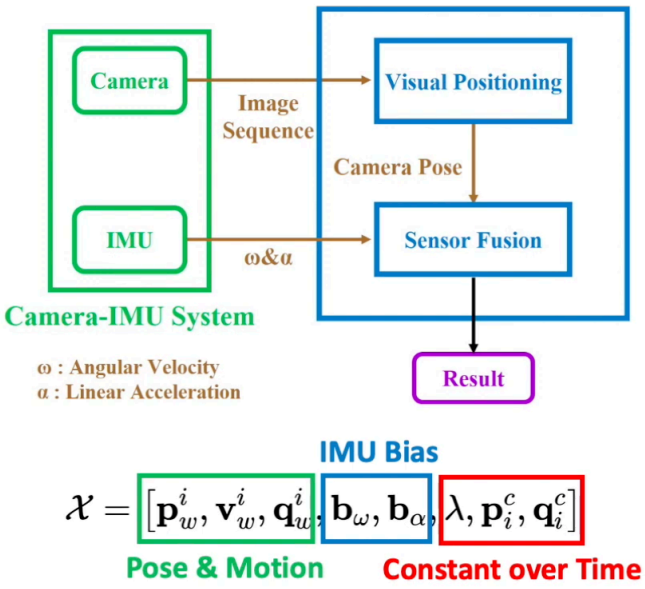
Inertial measurements

External reference

Optical or other observations

Combined estimate

Pose with reduced drift



Camera–IMU fusion example

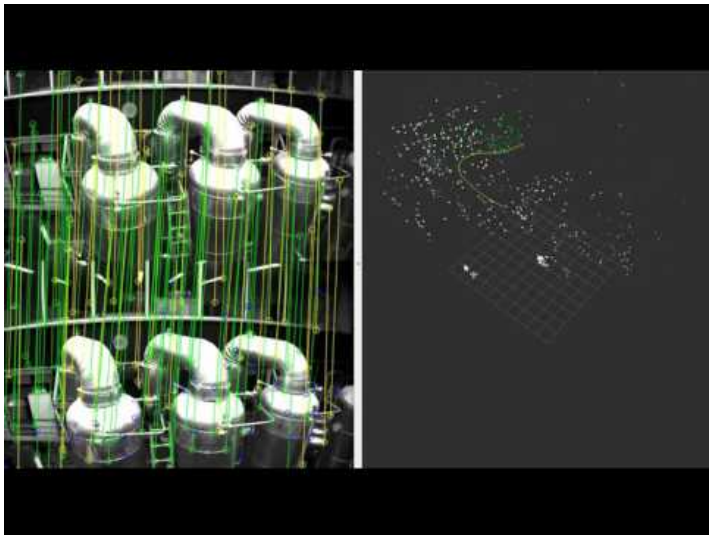
COURSE NOTES

Sensor fusion combines measurements with different strengths. Inertial sensing supports rapid motion updates; observations of a referenced environment can constrain accumulated drift. The estimation algorithm needs a model of the sensors, their uncertainty and the tracked motion. A human sensory organ and an engineering sensor do not have a simple one-to-one equivalence.

The diagram illustrates a camera–IMU fusion example: visual positioning and inertial measurements contribute to a common estimate. The state vector details belong to the authors' method. Illustration: https://kuan-wei-tseng.github.io/images/complementary.png

5.1 Motion capture

Sensor fusion: OKVIS



OKVIS: Open Keyframe-based Visual-Inertial SLAM

Watch the video ↗

COURSE NOTES

OKVIS: Open Keyframe-based Visual-Inertial SLAM — Stefan Leutenegger.
https://www.youtube.com/watch?v=TbKEPA2_-m4

5.1 Motion capture

Tracking quality

Accuracy

Closeness to the reference pose

Jitter

Rapid variation around an estimate

Drift

Accumulating displacement over time

Loss and recovery

Behaviour when observations disappear

COURSE NOTES

Different tracking errors create different user-visible problems. A fixed offset differs from high-frequency shaking or slowly accumulating drift. Loss of tracking needs an explicit application response, especially while holding an object or moving. Test under realistic lighting, workspace and body occlusion conditions.

Controllers

Half-Life: Alyx



Valve Index



Half-Life: Alyx

Watch the video ↗

COURSE NOTES

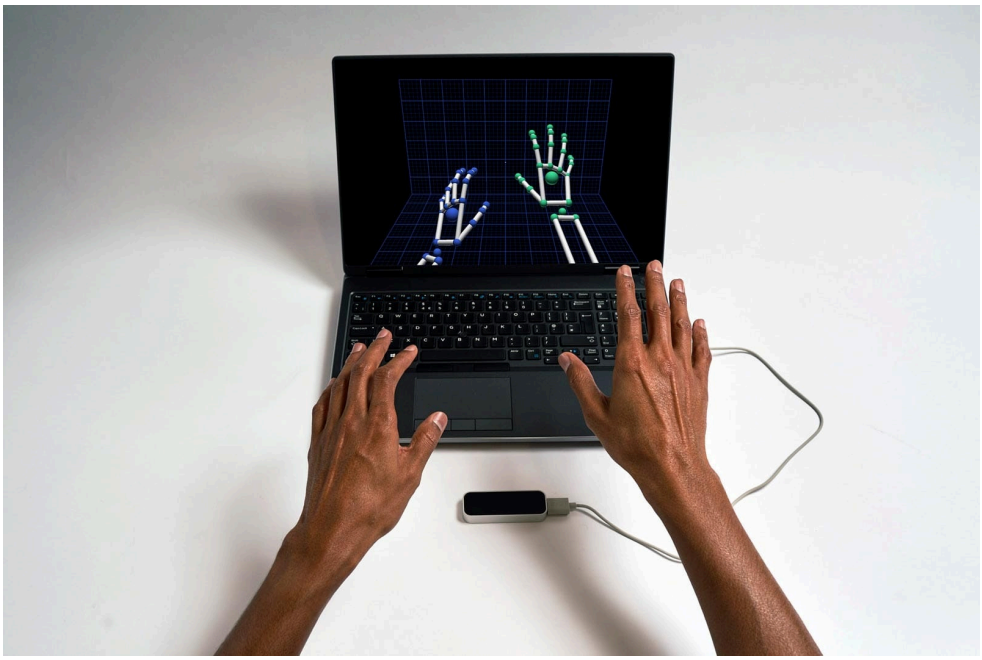
A controller is a tracked rigid object. Its pose describes its position and orientation, rather than the configuration of every finger. Buttons, triggers and thumbsticks provide inputs separate from pose.

A button press can confirm a selection while controller motion moves a grasped object. Vibration can signal contact without mechanically resisting movement. Depending on the technology and controller position, occlusion or leaving the tracking volume can degrade pose estimates. Tracking alone does not guarantee usable interaction.

Illustration: https://store.steampowered.com/app/1059550/Valve_Index_Controllers/
Demonstration: https://docs.ultraleap.com/ultralab/vr-gaming-controllers-and-hands.html

Hand tracking

Silhouette · Ultraleap



Leap Motion



Silhouette · Ultraleap

Watch the video ↗

COURSE NOTES

Hand tracking reconstructs an articulated skeleton from observations. A joint estimate can become uncertain when another finger, the other hand or an object hides it. Hands must remain within the cameras' observable region.

A pinch is one possible command: bringing the thumb and index finger together can trigger selection or grasping. Distinguish the estimated hand pose, gesture recognition and the action assigned by the application.

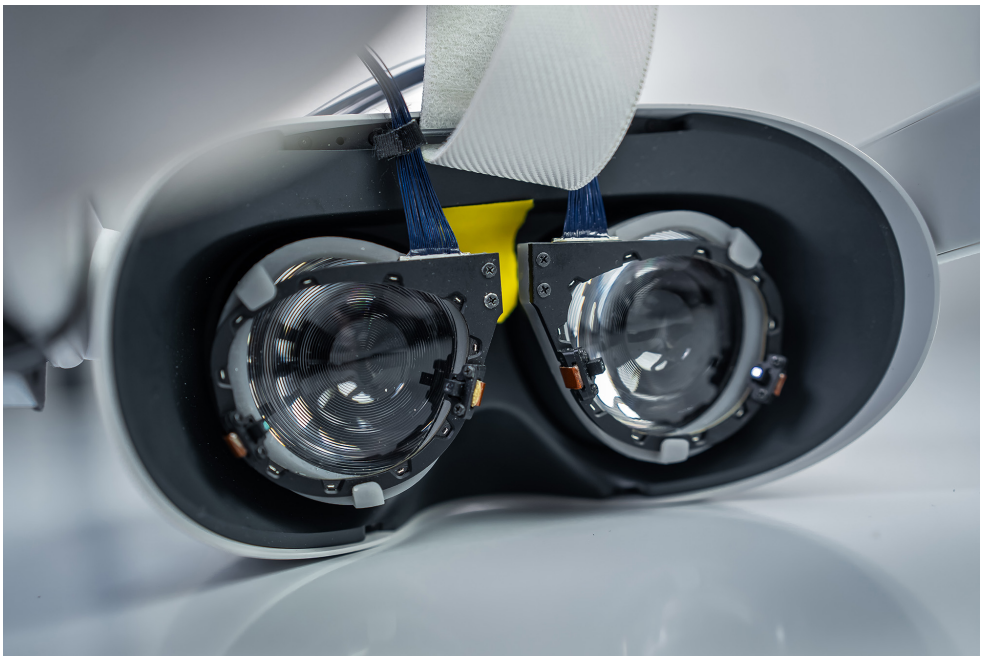
The illustration shows a Leap Motion sensor and estimated joints on screen. The Silhouette video shows interaction through hands and their shadows, as presented in Ultraleap's documentation. Optical tracking alone provides no mechanical resistance.

Illustration: https://documentation.ls-group.fr/interact/LeapMotion/ Demonstration: https://docs.ultraleap.com/ultralab/vr-gaming-controllers-and-hands.html

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Eye tracking

Tobii VR Integration Demo



Tobii



Tobii VR Integration Demo

Watch the video ↗

COURSE NOTES

Head-gaze uses headset orientation. It approximates the direction being looked at: the eyes can move without the head moving. Eye tracking uses dedicated sensors to estimate gaze direction.

Eye tracking may require user-specific calibration. Accuracy and data availability depend on the device and operating conditions. A gaze direction is neither proof of attention nor an explicit selection intent.

Gaze-and-commit separates targeting from confirmation. A button, pinch gesture or dwell time can confirm an action. Separate confirmation lets users visually explore the scene without every glance triggering an action.

References: Microsoft Learn, Eye tracking overview, https://learn.microsoft.com/en-us/windows/mixed-reality/design/eye-tracking and Eye-gaze-based interaction, https://learn.microsoft.com/en-us/windows/mixed-reality/design/eye-gaze-interaction

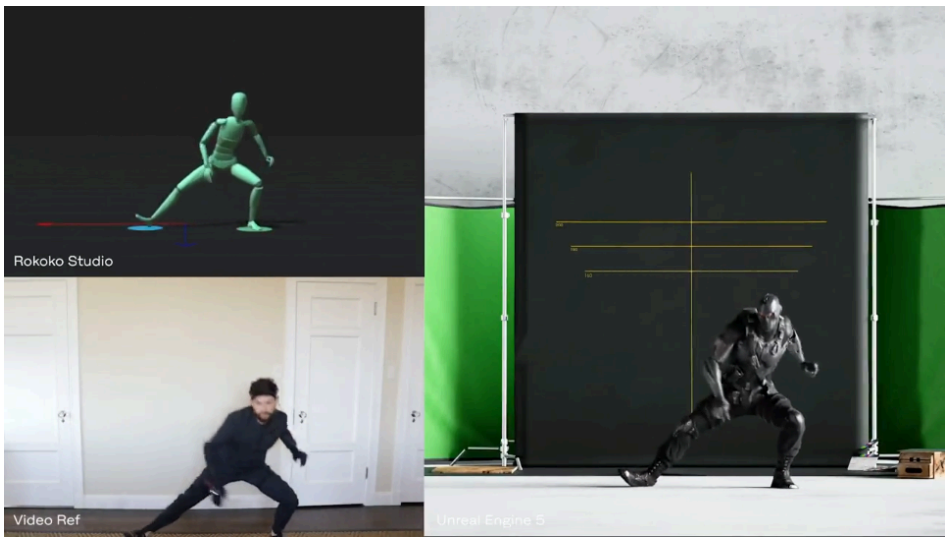
Illustration: https://www.tobii.com/resource-center/learn-articles/how-do-eye-trackers-work
Demonstration: https://video.tobii.com/tobii-vr-integration-demo

Body tracking

Rokoko · Smartsuit Pro II



Smartsuit Pro II



Smartsuit Pro II · Rokoko Studio / Unreal Engine

Watch the video ↗

COURSE NOTES

Body tracking can use cameras, optical markers or wearable sensors. The number and placement of observations determine which segments have supporting measurements. Not every segment visible on an avatar is necessarily measured.

Inverse kinematics can infer a posture compatible with tracked points and a skeleton model. If only the head and hands are tracked, several elbow and body configurations can fit the same observations. Reconstruction therefore requires constraints and assumptions.

A mismatch between real movement and avatar movement can disrupt coordination and bodily experience. Distinguish available measurements from reconstructed segments and match avatar detail to tracking quality. The avatar animation section returns to this mapping.

Illustration and video: Rokoko Smartsuit Pro II. The demonstration compares the recorded performer, the skeleton in Rokoko Studio and the character in Unreal Engine. Source: https://www.rokoko.com/products/smartsuit-pro

5.2

Sensory output

COURSE NOTES

This section follows seven stimulation types: vision, hearing, haptics, proprioception, vestibular stimulation, smell and taste. Each block starts with the intended perceptual effect, introduces device families, then groups their examples. Augmented reality belongs to the visual block. Airflow that stimulates the skin belongs to haptics.

These categories organise the presentation by intended effect. They are not independent channels: walking also engages touch, the vestibular system and vision. A device can contribute to several sensory experiences.

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Online slide ↗

5.2 Sensory output · Vision

Visual stimulation

Present a scene, its depth and changes in viewpoint

COURSE NOTES

These categories organise the presentation by intended effect. They are not independent channels: walking also engages touch, the vestibular system and vision. A device can contribute to several sensory experiences.

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Online slide ↗

5.2 Sensory output · Vision

Families of visual displays

Head-mounted displays

An image displayed in front of the eyes

Projection and screens

A physical surface shared by or surrounding users

Augmented reality

The physical world remains visible with added content

COURSE NOTES

A headset’s visual experience depends on optics, field of view, resolution, frame timing and fit. Visual immersion is the dominant example in this course, while immersive applications can also centre on other senses. Device categories do not by themselves determine comfort or presence. Check what the optics and display actually present to each eye.

Head-mounted display: FlyVIZ



FlyVIZ : un casque qui permet de voir à 360°

Watch the video ↗

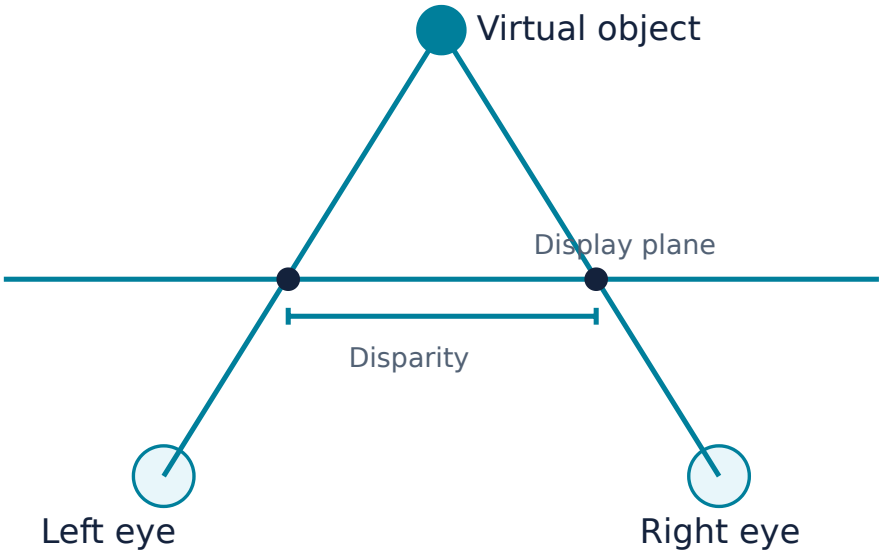
COURSE NOTES

The viewing arrangement determines which movements change the displayed perspective and how the observer relates the image to the surrounding space. A fixed screen, a projection surface and a head-mounted display impose different relationships between head position and image formation. Tracking and calibration allow the visual result to remain coherent with the observer’s movement.

FlyVIZ : un casque qui permet de voir à 360° — ESIEA. https://www.youtube.com/watch?v=HqZLOdtaCHo

FlyVIZ is a mediated-vision example: a captured 360° scene is presented through a head-mounted display. It is not representative of every immersive headset.

Immersive projection: a CAVE





Beck et al. (IEEE VR 2013)

Watch the video ↗

COURSE NOTES

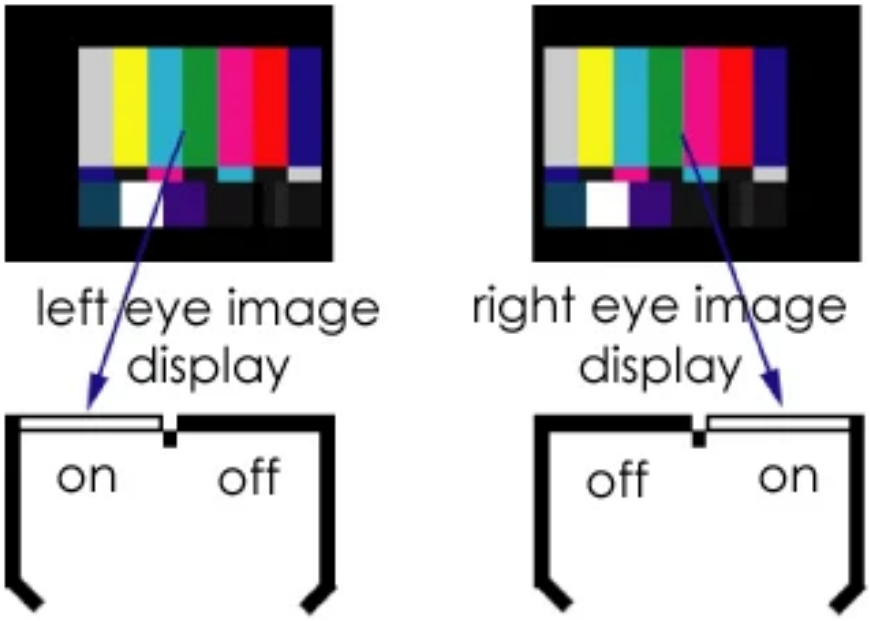
Projection systems need calibrated geometry and viewpoint-dependent rendering. Several people can occupy the room, but a shared stereo image pair is geometrically correct only for the intended tracked viewpoint. Multi-view systems can address some constraints at additional complexity. The visible physical body and access to props can be useful.

A headset and a projection room can both support immersive experiences. Their constraints differ in field of view, optical properties, mobility, visibility of the physical body and collaboration. Tracked projection must generate an image appropriate to the observer's position. Device selection follows the task, rather than a single hierarchy of immersion.

Correct stereo rendering requires more than offsetting two images. The eye locations and display geometry determine the projections. A CAVE or desktop display needs off-axis rendering as the observer moves. The two eye views should remain consistent with world scale and the participant's calibrated interocular distance.

Remote collaboration depends on which information about others becomes available. Fleury and colleagues' simplified avatars communicate position and action in a shared environment. Beck and colleagues' group telepresence uses three-dimensional video-related representations and collaboration tools. These arrangements make different aspects of posture, expression and shared activity visible; appearance and coordination are related but distinct design questions.

Active stereo: shutter glasses



Alternating left and right views, synchronised with the glasses

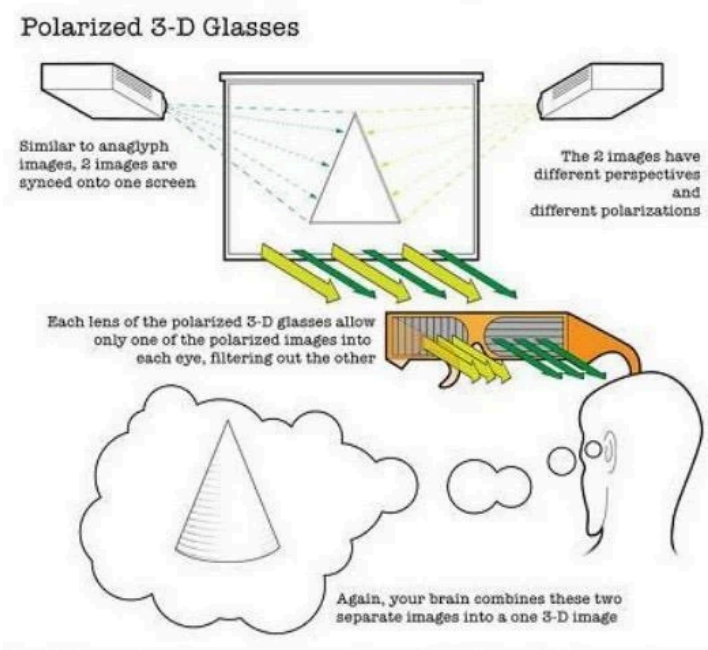
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COURSE NOTES

Active glasses alternately open the left and right shutters. The screen displays the corresponding view at the same time. The diagram shows both phases of this alternation.

The display and glasses must remain synchronised. Temporal separation alone does not determine how the two viewpoints are calculated.

Passive stereo: polarisation



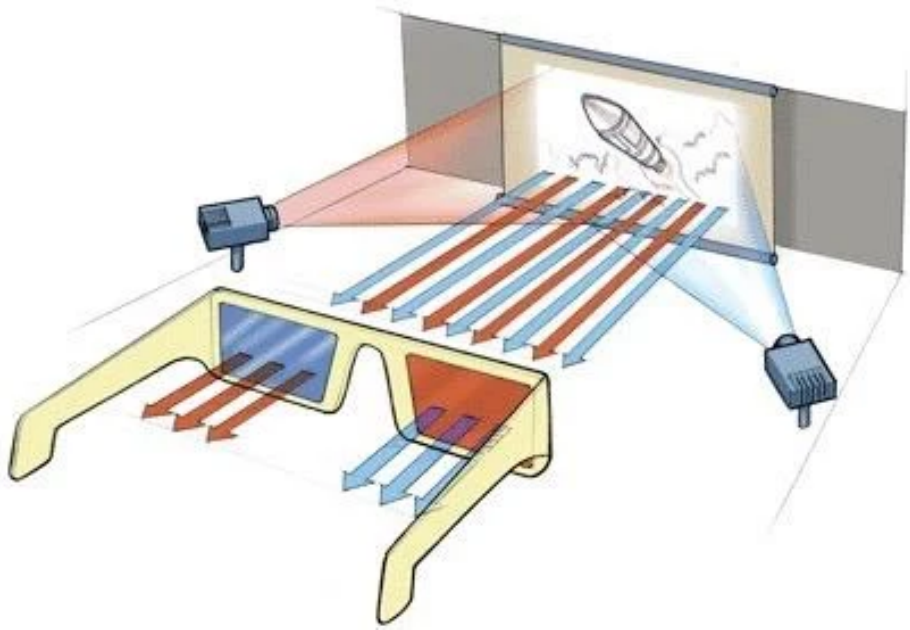
Two polarisations, one view for each eye

COURSE NOTES

Two images with different polarisations overlap on the screen. Each lens filters light to transmit mainly the view intended for the corresponding eye.

The diagram illustrates projection through two polarised channels. The glasses are passive. Separation depends on the screen preserving polarisation and the filters matching the projected channels.

Anaglyph stereo



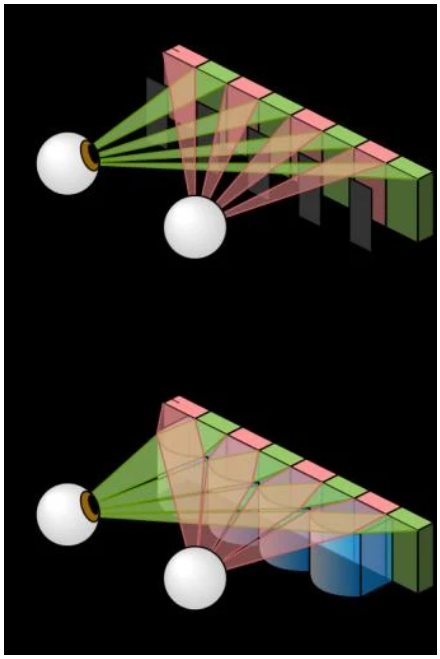
Views separated by colour filters

COURSE NOTES

The two views use different colour channels. Coloured filters in the glasses separate the images intended for each eye.

The diagram illustrates chromatic filtering. Separation depends on the colours and filters chosen and alters the scene’s colour reproduction.

Autostereoscopic displays



Views directed to each eye, without glasses

COURSE NOTES

The display directs different views towards the two eyes without glasses. The diagram shows a parallax barrier above and a lenticular array below.

Both eyes must lie within suitable viewing zones. View count and freedom of movement depend on the device. Directional view separation is distinct from calculating the geometry of the views.

Multi-user projection: C1x6



Multi-stereoscopic display research

Watch the video ↗

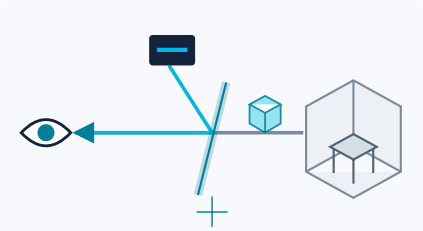
COURSE NOTES

A single shared stereo pair has one intended viewing geometry. Multi-viewer systems add ways to separate several sets of views. The demonstration illustrates a specialised arrangement; the available number of views, brightness and temporal resolution depend on the implementation. It explains why simply adding another tracked person is insufficient.

Augmented reality techniques

Optical see-through

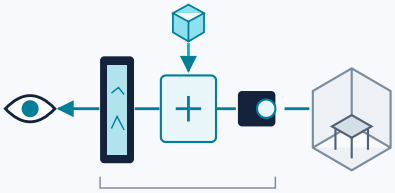
Direct optical view



Real light + optically added virtual content

Video see-through

Camera-mediated view



Camera → composition → display → eye

Handheld display

Phone or tablet



The screen is a window onto the augmented scene

COURSE NOTES

The diagrams show the path from the physical scene to the eye. Grey represents the real scene; cyan represents virtual content and its display path. Each illustration shows a different viewing arrangement.

Optical see-through: light from the real environment passes through a transparent optical combiner toward the eye. A projection system adds virtual imagery to that optical path. The physical world remains directly visible through the optics.

Video see-through: cameras capture the physical scene. Their images are combined with computer-generated content and the result is presented on a display. The eye sees the displayed camera view rather than looking through a transparent optical path.

Handheld display: a phone or tablet captures the scene with its camera and shows the augmented result on its screen. The user looks at this screen while the surrounding physical world remains visible around it. This is a device arrangement, usually using video see-through, rather than a third independent optical principle. Head-mounted displays can use optical or video see-through.

Augmented reality: examples

Optical see-through: HoloLens



HoloLens archive

Watch the video ↗

Handheld display: ARKit



ARKit demonstration

Watch the video ↗

COURSE NOTES

HoloLens illustrates optical see-through augmentation: the physical scene remains visible through the optics while virtual imagery is added. The design question is how the virtual content is positioned and updated relative to surfaces and the moving observer. Alignment, visibility and the correspondence between gesture and response determine whether the added content can serve the intended activity.

ARKit illustrates augmentation through a handheld camera view. The system estimates how the device moves and how virtual content relates to the filmed scene. The screen combines the camera image and rendered objects, while the surrounding physical space remains directly visible around the device. Maintaining registration as the camera moves is central to the illusion of an object located in the room.

Slide 29 / 56

Online slide ↗

5.2 Sensory output · Hearing

Auditory stimulation

Make events audible and let the listener locate sound sources

COURSE NOTES

These categories organise the presentation by intended effect. They are not independent channels: walking also engages touch, the vestibular system and vision. A device can contribute to several sensory experiences.

Slide 30 / 56

Online slide ↗

5.2 Sensory output · Hearing

Families of audio output

Headphones

Binaural rendering for the two ears

Loudspeakers

Physical sources and spatial reproduction arrays

COURSE NOTES

Spatial audio rendering computes the relation between sound sources and the listener. A world-fixed sound changes relative to the ears when the head turns, while remaining associated with its location in the scene. Headphones and loudspeaker arrays require different spatialisation and calibration arrangements. Speech, events and guidance can have different mixing priorities so that relevant signals remain audible and interpretable.

Slide 31 / 56

Online slide ↗

5.2 Sensory output · Hearing

3-D audio demonstration

Use headphones · enable sound



3-D Audio Demo

Watch the video ↗

COURSE NOTES

3-D Audio Demo — Microsoft Research. https://www.youtube.com/watch?v=wtFgLi6XKrY

Slide 32 / 56

Online slide ↗

5.2 Sensory output · Touch and forces

Haptic stimulation

Create sensations of contact, vibration and object resistance

COURSE NOTES

These categories organise the presentation by intended effect. They are not independent channels: walking also engages touch, the vestibular system and vision. A device can contribute to several sensory experiences.

Slide 33 / 56

Online slide ↗

5.2 Sensory output · Touch and forces

Families of haptic output

Cutaneous feedback

Vibration, pressure and stimulation of the skin

Kinesthetic feedback

Forces and resistance applied to movement

COURSE NOTES

Tactile interfaces stimulate skin-related sensations. The examples include vibration, distributed stimulation and an air-based demonstration. These examples differ in what they can reproduce. A brief vibration can signal contact without physically constraining movement. The temporal and spatial relation to the visible event still matters.

A force-feedback interface can both measure movement and apply forces. The examples include articulated arms, cable systems and exoskeletons. Workspace, force range, backdrivability and stable control constrain the interaction. Force feedback requires a physical mechanism; it differs from a pseudo-haptic impression produced by visual manipulation.

Cutaneous feedback with contact

Vibrating controller: Joy-Con



1-2-Switch — Ball Count (Nintendo)

Watch the video ↗

Vibrating vest: bHaptics



bHaptics Tactsuit X40&X16 Overview

Watch the video ↗

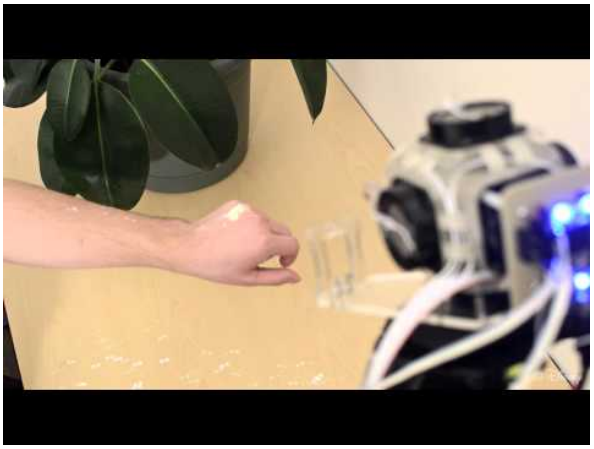
COURSE NOTES

Both examples use actuators in contact with the body to transmit vibration to the skin. In 1-2-Switch Ball Count, Joy-Con HD rumble creates the impression of balls rolling inside the controller. The TactSuit vest distributes vibrations across the torso to signal game events.

These vibrations provide cutaneous feedback. They can suggest an impact or contact without applying the movement constraints of a solid object. The Joy-Con example illustrates a stimulation principle also used by VR controllers.

Contactless cutaneous feedback

Air vortices: AIREAL



AIREAL: Interactive Tactile Experiences in Free Air

Watch the video ↗

Ultrasound: Touchable Holography



Touchable Holography

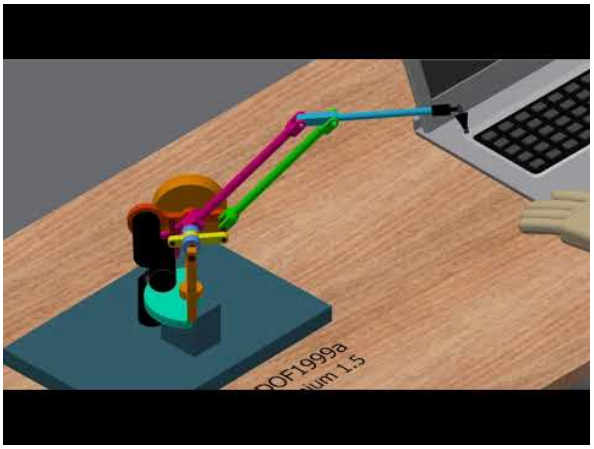
Watch the video ↗

COURSE NOTES

AIREAL stimulates the skin with air vortices. Touchable Holography uses airborne ultrasound to create tactile sensations without direct contact.

Force-feedback arms

Stylus: PHANTOM Premium 1.5



Sensable3DOF1999a (Phantom Premium 1.5)

Watch the video ↗

Arm: Haption Virtuose 6D



Virtuose 6D — HAPTION

Watch the video ↗

COURSE NOTES

A motorised articulated arm measures its endpoint pose and applies forces to the hand through a stylus or handle. Its controller can render resistance when contacting a virtual surface. A grounded support reacts the applied forces.

The PHANTOM Premium 1.5 video from the Haptipedia project shows a desktop stylus device. Haption’s video presents the Virtuose 6D, which renders forces and torques across six degrees of freedom. Sensed degrees of freedom and actuated degrees of freedom must be distinguished.

Force feedback: examples

Cables: SPIDAR-8



Two-Handed Multi-Fingers Haptic Interface Device: SPIDAR-8

Watch the video ↗

Gloves: SenseGlove Nova 2



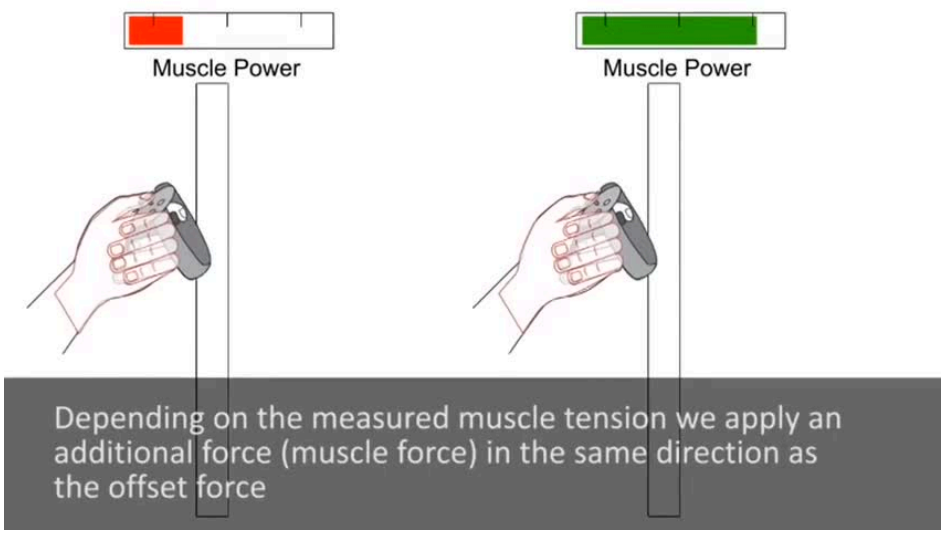
Nova 2 in Action: Seamless Compatibility with the Most Popular XR Headsets

Watch the video ↗

COURSE NOTES

A force-feedback interface can both measure movement and apply forces. The examples include articulated arms, cable systems and exoskeletons. Workspace, force range, backdrivability and stable control constrain the interaction. Force feedback requires a physical mechanism; it differs from a pseudo-haptic impression produced by visual manipulation.

Force assistance driven by muscle activity



Force assistance driven by muscle activity

Watch the video ↗

COURSE NOTES

The animation illustrates an additional force applied in the direction of the user’s effort according to measured muscle tension. This is active physical assistance: a mechanism applies a real force. A pseudo-haptic effect instead changes visual feedback to influence the perceived relation between effort and result. The two approaches can both alter the experience of effort, but act through different means.

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Online slide ↗

5.2 Sensory output · Posture and movement

Proprioceptive stimulation

Engage the sense of the body’s position and movement

COURSE NOTES

These categories organise the presentation by intended effect. They are not independent channels: walking also engages touch, the vestibular system and vision. A device can contribute to several sensory experiences.

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5.2 Sensory output · Posture and movement

Families of movement interfaces

Active walking

Treadmills, moving surfaces and spherical devices

Assisted movement

Supports and mechanisms that guide the body

COURSE NOTES

Locomotion interfaces include mobile platforms, treadmill systems, a locomotion sphere and redirected-support mechanisms. These are different engineering strategies. No finite platform can reproduce an arbitrary journey’s sustained acceleration. The navigation course examines how each device connects bodily action to virtual displacement.

These categories organise the presentation by intended effect. They are not independent channels: walking also engages touch, the vestibular system and vision. A device can contribute to several sensory experiences.

Moving walking surface



Moving walking surface

Watch the video ↗

COURSE NOTES

Compare the moving surface, spherical enclosure and movable support geometry. Identify what the participant actually moves against and how the system returns them toward a usable physical position. Each mechanism changes the relation between gait and virtual travel.

Spherical locomotion interface



Spherical locomotion interface

Watch the video ↗

COURSE NOTES

Compare the moving surface, spherical enclosure and movable support geometry. Identify what the participant actually moves against and how the system returns them toward a usable physical position. Each mechanism changes the relation between gait and virtual travel.

Movable support surface



Movable support surface

Watch the video ↗

COURSE NOTES

Compare the moving surface, spherical enclosure and movable support geometry. Identify what the participant actually moves against and how the system returns them toward a usable physical position. Each mechanism changes the relation between gait and virtual travel.

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5.2 Sensory output · Balance

Vestibular stimulation

Create a sensation of acceleration or tilt

COURSE NOTES

These categories organise the presentation by intended effect. They are not independent channels: walking also engages touch, the vestibular system and vision. A device can contribute to several sensory experiences.

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Online slide ↗

5.2 Sensory output · Balance

Families of vestibular stimulation

Physical movement

Platforms that accelerate or tilt the participant

Galvanic stimulation

Electrical interfaces investigated in research

COURSE NOTES

A motion platform changes bodily acceleration mechanically. Galvanic vestibular stimulation uses electrical current to influence vestibular signals and appears in specialised research. Effects depend on the apparatus, exposure and experimental protocol. This research topic does not establish a general comfort benefit or a suitable classroom implementation.

Motion platform: flight simulator



Motion-platform and vestibular-stimulation research examples

COURSE NOTES

Motion platforms combine visual scenes, controls and physical displacement. Available translations and rotations depend on the mechanism. Because the workspace is finite, a platform cannot reproduce sustained travel by continuing indefinitely in the same direction. Motion cueing must therefore relate bounded physical movement to the simulated trajectory, while visual rendering follows the intended viewpoint.

Motion platforms: seat and hexapod

Seat: Motion Platform V3



Next Level Racing Motion Platform V3

Watch the video ↗

Hexapod: PS-6TL-250



Patron VT Presentation ENG

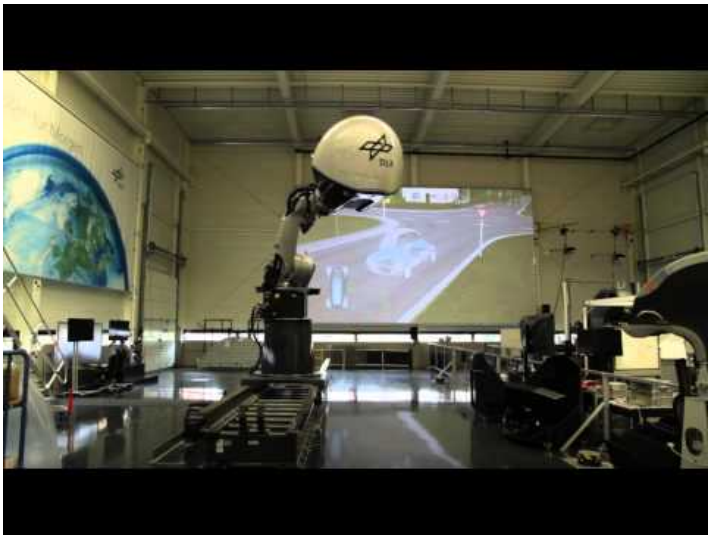
Watch the video ↗

COURSE NOTES

Next Level Racing’s Motion Platform V3 moves the seat to accompany a driving or flight simulation. The second video shows PatronVT, a truck and bus driving simulator using Motion Systems’ PS-6TL-250 hexapod platform.

These examples distinguish a moving seat from an assembly mounted on a six-degree-of-freedom platform. Physical movement provides acceleration and tilt cues coordinated with the visual scene. Actuator travel and workspace limit the motion that can be produced.

Robotic motion platform: DLR simulator



DLR Robotic Motion Simulator - Driving Simulation

Watch the video ↗

COURSE NOTES

The DLR Robotic Motion Simulator uses an industrial robot arm carrying a cabin. DLR’s video shows a RoboMobil driving simulation and the cabin’s physical motion. This serial mechanism is an alternative to a hexapod platform with linear actuators.

The cabin moves the participant to provide inertial cues coordinated with the visual scene. This is vestibular stimulation through physical movement. It differs from the hand-operated force-feedback arms presented in the haptic block.

Galvanic vestibular stimulation



Omnidirectional Galvanic Vestibular Stimulation in Virtual Reality - Fast Forward | VIS 2022

Watch the video ↗

COURSE NOTES

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Omnidirectional Galvanic Vestibular Stimulation in Virtual Reality - Fast Forward | VIS 2022 — IEEE Visualization Conference. https://www.youtube.com/watch?v=lUH0qri84Qk

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Online slide ↗

5.2 Sensory output · Smell

Olfactory stimulation

Present a smell associated with an object or environment

COURSE NOTES

These categories organise the presentation by intended effect. They are not independent channels: walking also engages touch, the vestibular system and vision. A device can contribute to several sensory experiences.

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Online slide ↗

5.2 Sensory output · Smell

Families of olfactory interfaces

Ambient delivery

A scent is released into the environment

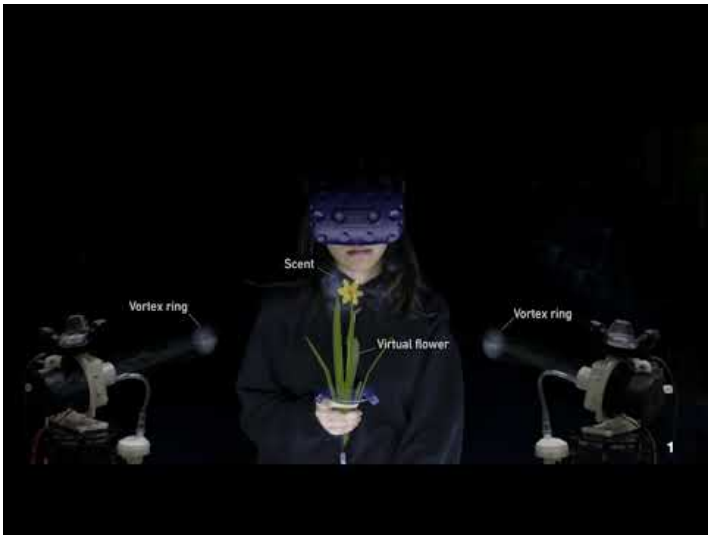
Local delivery

A device is worn or brought close to the nose

COURSE NOTES

Delivery, onset and dissipation determine control over scent stimuli. Odours and tactile airflow are treated separately in this course.

Olfactory output: aBio



aBio: Active Bi-Olfactory Display Using Subwoofers for Virtual Reality

Watch the video ↗

COURSE NOTES

aBio: Active Bi-Olfactory Display Using Subwoofers for Virtual Reality — hu youyang.
https://www.youtube.com/watch?v=R53b0H5C-IM

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5.2 Sensory output · Taste

Gustatory stimulation

Present tastes or alter the perceived flavour of food

COURSE NOTES

These categories organise the presentation by intended effect. They are not independent channels: walking also engages touch, the vestibular system and vision. A device can contribute to several sensory experiences.

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Online slide ↗

5.2 Sensory output · Taste

Families of taste interfaces

Taste substances

Solutions or gels in contact with the tongue

Electrical modulation

Electrodes or controlled transport of substances

Multisensory approaches

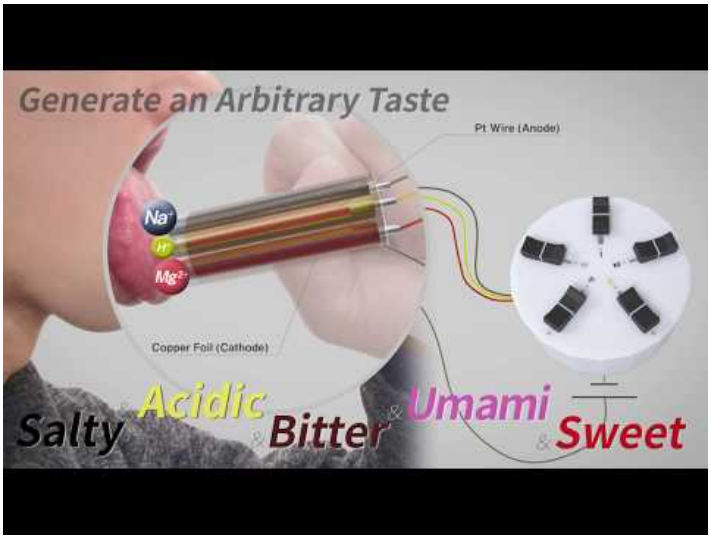
Alter perceived flavour through vision and smell

COURSE NOTES

Norimaki Synthesizer uses five gels and controls ion transport through electrophoresis. The current modulates the contribution of taste substances; it should not be confused with direct electrical stimulation of the tongue. Taste differs from flavour, which also depends on smell and other sensations.

Meta Cookie illustrates a multisensory approach: a real cookie is paired with an altered appearance in augmented reality and added scents. Cross-modal interaction can change perceived flavour without changing the cookie’s ingredients.

Taste output: Norimaki Synthesizer



[CHI2020] Norimaki Synthesizer: Taste Display Using Ion Electrophoresis in Five Gels

Watch the video ↗

COURSE NOTES

Norimaki Synthesizer uses five gels and controls ion transport through electrophoresis. The current modulates the contribution of taste substances; it should not be confused with direct electrical stimulation of the tongue. Taste differs from flavour, which also depends on smell and other sensations.

[CHI2020] Norimaki Synthesizer: Taste Display Using Ion Electrophoresis in Five Gels — □□□□ □ □□□□. https://www.youtube.com/watch?v=7HIm4LoAZxU

Meta Cookie: vision, smell and taste



Meta Cookie at Exploratorium After Dark

Watch the video ↗

COURSE NOTES

Meta Cookie, developed by Takuji Narumi and colleagues at the University of Tokyo, overlays a different appearance on a real cookie and delivers associated scents. It aims to alter perceived flavour through interaction between vision, olfaction and gustation. The cookie’s ingredients remain the same.

The video shows a demonstration at the Exploratorium. The device changes the multisensory context of eating rather than directly stimulating taste receptors on the tongue. Perceptual effects depend on conditions and participants.