3

Applications of virtual reality

Design, train, care, explore, meet

Étienne Peillard
IMT Atlantique

COURSE NOTES

The usefulness of VR depends on the activity it supports. Designing, training, caring, creating and investigating call for different information and interactions. An operational application, an artistic work and a research prototype also provide different kinds of evidence about what VR makes possible.

The opening question is: what is VR used for today? Familiar answers such as games and training provide an initial inventory. Industrial examples then introduce uses that are less visible from a consumer perspective. Not owning a headset at home says little about its value for a professional activity.

What is virtual reality used for?

Five application families, one question: what does VR add to the activity?

1 Applications

Design and industry
Inspect a system before manufacturing

2 Applications

Training and skills
Practise a task and assess learning

3 Applications



Healthcare and clinical uses
Support a defined intervention

4 Applications



Culture and entertainment
Experience a place or a work

5 Applications



Social virtual reality
Meet and act together

1–5 · Application families 6 · Choosing and evaluating a use 7 · Further examples and research

COURSE NOTES

The overview distinguishes five families: design and industry, training, healthcare, culture and entertainment, and social VR. They overlap: a visit may be collective and a care exercise may involve other people. Classify examples by their purpose. Synthesis ends the main route; additional examples and research follow. Collect student examples and revisit their choices at the conclusion.

Slide 3 / 91

Online slide ↗

Part 1 of 7

3.1
Design and industry

Which decision can be made before manufacturing?

COURSE NOTES

Virtual prototypes allow design questions before a physical prototype exists. The examples include product appearance, seat insertion, manufacturing processes and workstation ergonomics. Fidelity must support the question being asked: correct dimensions and reach may matter more than surface appearance. A model can omit physical constraints unless those constraints are explicitly simulated.

Slide 4 / 91

Online slide ↗

Application principle

3.1 Design and industry

Can this part be assembled?

Access to the fastener

Can the tool and hand reach the target?

Assembly order

Which part must be positioned first?



Vehicle design review



Assembly and workstation analysis

> Decision: change the design before manufacturing.

COURSE NOTES

Virtual prototypes allow design questions before a physical prototype exists. The examples include product appearance, seat insertion, manufacturing processes and workstation ergonomics. Fidelity must support the question being asked: correct dimensions and reach may matter more than surface appearance. A model can omit physical constraints unless those constraints are explicitly simulated.

Existing digital models provide the starting point. VR allows inspection at body scale: can a worker reach a fastener, insert a tool and assemble parts in the intended order? The lecture contrasts modifications to a physical assembly mock-up with inspection of a digital version. The key question is which decision becomes possible before manufacturing. Access constraints and collisions must be represented for that inspection to be meaningful.

Architecture and spatial design

Human scale

Experience proportions and circulation

Alternative proposals

Compare design choices

Immersive authoring

Create and modify in space



VR Sketch: design in SketchUp using VR

Watch the video ↗

COURSE NOTES

VR Sketch illustrates design directly within a spatial model. Changing between model scale and human scale supports different questions: the overall organisation of a building and the experience of occupying a particular room. Editing geometry in that setting connects creation with inspection. These tasks require explicit tools for selection, precision and scale changes.

Having a CAD model does not mean having a scene ready for a headset. The lecture stresses preparation: a model intended for detailed rendering may require substantial simplification for interactive exploration. Geometry, materials and levels of detail must support the visit while maintaining fluidity. This conversion contributes to project cost even when 3D content already exists.

From CAD model to immersive visit

Stage	Design question
CAD model	Which elements support the task?
Scene preparation	Which details can be simplified?
Headset trial	Is the visit fluid and readable?

> Existing 3D content still requires preparation.

COURSE NOTES

A design model can contain manufacturing details that do not help a visit. Preparation preserves task-relevant information while adapting the scene to the device. Geometry, materials and levels of detail need examination. For circulation checks, passage width matters more than an invisible screw. Ask which details to retain, then check fluidity on the target hardware. Conversion time is part of project cost.

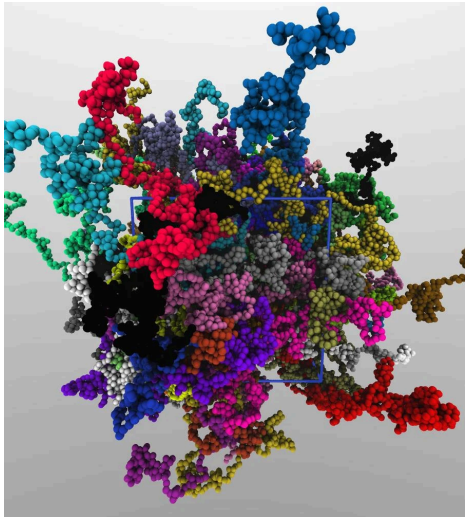
Understanding a structure generated in 3D

Spatial question

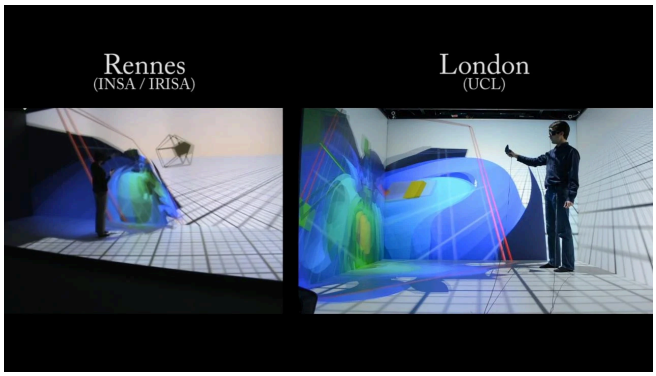
Where does the flow go? Which layers intersect?

Exploration

Change viewpoint or representation



Scientific and industrial 3D data



Visual comparison of simulated phenomena

> Understanding also depends on tools and expertise.

COURSE NOTES

The examples include flow, temperature and scientific structures. Spatial viewing can help reveal relationships, but a 3D display is not automatically the clearest way to answer every data question. Discuss the role of abstraction, comparison, colour and task-specific interaction. These are historical demonstration clips, not claims about current products.

The lecture emphasises preserving the spatial dimension of data generated in 3D. Screen projections require some mental reconstruction, particularly when layers overlap. Immersion offers another way to inspect these relationships. Comparisons must account for expertise

with existing tools: interpreting 2D slices is itself a learned skill. VR should be assessed through understanding achieved on a specific task.

Slide 8 / 91 Online slide ↗

3.1 Design and industry

Screen or immersion: the same spatial question

Same task: locate a flow	Screen	Immersion
Access the structure	Slices, rotation, views	Moving viewpoint, spatial exploration
Assess the contribution	Same question and same data	Compare errors, time and effort

> Choose a representation for a specific task.

COURSE NOTES

Both conditions must use the same data and question. Screens can offer slices and controlled views; immersion adds exploration through viewpoint and body movement. Compare localisation errors and effort to understand a structure, accounting for expertise. Images in the preceding overview depict distinct examples, not an experiment comparing the same dataset.

Slide 9 / 91 Online slide ↗

Industrial deployment · 2025 3.1 Design and industry

BMW: production planning at scale

Shared factory data

Layouts, equipment and logistics

Before physical changes

Simulate clearances and production flows

Reported scale

Digital twins of over 30 production sites



© BMW Group · Virtual Factory, 2025

> Separate the industrial simulation from the immersive interface.

COURSE NOTES

BMW reported scaling Virtual Factory applications across digital twins of more than 30 production sites in June 2025. The platform combines industrial data and simulation to support planning. This is evidence of an operational digital-twin workflow, not a controlled demonstration of the added benefit of a headset. Immersive review is one possible interface to such a world; automated collision checks and desktop tools do not require VR.

The lecture introduces a digital twin as a virtual representation connected to information about a physical system, its state and activity. A geometric model describes shapes; a twin project adds data for monitoring or simulation. Specify what is updated and how frequently rather than assuming a perfectly exact, instantaneous copy. VR can provide a spatial interface to this information. A factory-planning video alone does not demonstrate complete live synchronisation.

Model, simulation and digital twin

Model

Describe shapes and positions

Simulation

Compute behaviour within a scenario

Digital twin

Connect the model to physical-system data

> Which data are updated, from where and how often?

COURSE NOTES

These terms describe distinct functions. A model describes geometry; a simulation computes behaviour under specified conditions; a twin connects a representation with information about the physical system. Specify states, data origin and update frequency rather than assuming a perfect instantaneous copy. VR is one possible interface to that information. The BMW film presents an industrial workflow, not proof of every possible form of synchronisation.

3.1 Design and industry

Design: from geometry to a decision

Target decision

Access, assembly, circulation or data interpretation

Useful fidelity

Preserve constraints needed for the decision

Rivian design review ↗ Physical and virtual components ↗ Modelisar ↗

COURSE NOTES

Connect the preceding examples through the decision they support, rather than through the device they use. Ask what could be measured against a desktop review, a physical mock-up or a conventional engineering simulation.

Slide 12 / 91

Online slide ↗

Part 2 of 7

3.2
Training and skills

What is learned in the simulator?

COURSE NOTES

Training simulations can make expensive, rare or dangerous situations available for practice. A useful training system needs a task model, feedback and assessment. Reduced physical exposure in the simulation does not prove transfer to real work. Training outcomes must be evaluated against the skill being taught.

Slide 13 / 91

Online slide ↗

Application principle

3.2 Training and skills

Training for rare or risky situations

Repeatability

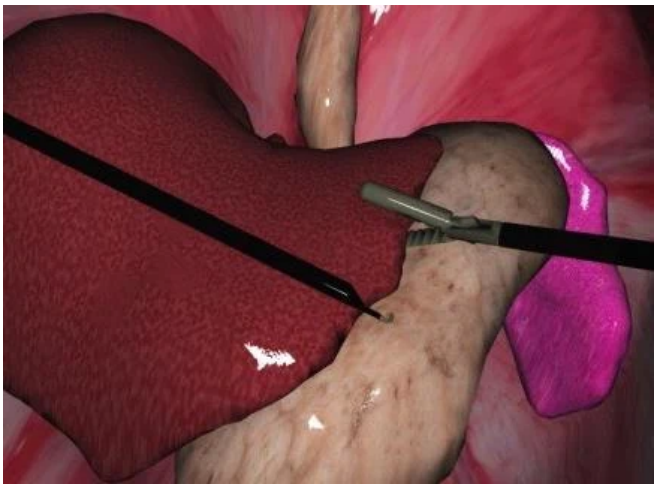
Practise the same situation

Controlled variation

Change task conditions

Reduced exposure

Simulate danger or unavailable equipment



Professional training example



Scenario-based training

COURSE NOTES

Training simulations can make expensive, rare or dangerous situations available for practice. A useful training system needs a task model, feedback and assessment. Reduced physical exposure in the simulation does not prove transfer to real work. Training outcomes must be evaluated against the skill being taught.

The lecture focuses on repeating situations, selecting events and observing learner actions. A scenario supports training when it belongs to a learning progression. Recorded actions can inform debriefing and selection of the next exercise. Repetition counts and collected measurements should be connected to a learning objective.

What is learned in the simulator?

Goal	Practice	Assessment
Understand the procedure	Order the actions	Omissions in the real situation
Adjust the movement	Connect action and sensory feedback	Accuracy and task errors
Adapt to a case	Vary events	Performance on a new variant

COURSE NOTES

The classroom discussion distinguishes understanding a procedure, adjusting a movement and adapting to a case. These are different goals. A scenario may prepare for a task, but transfer must be assessed outside the simulator. Force feedback and controls of a specialised simulator must match the demands of the movement. No general superiority or numerical reduction in training time is inferred from the oral account.

Procedures and team coordination

Individual skill

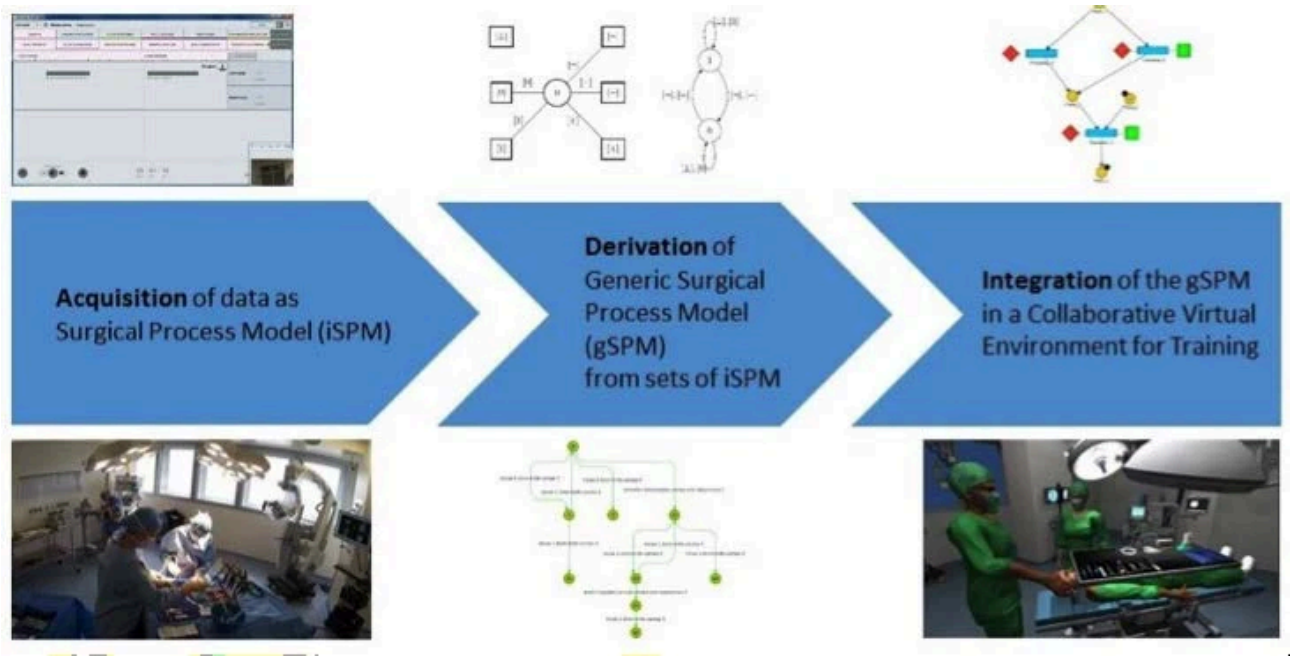
Tools and action sequences

Shared activity

Roles, timing and communication

Debriefing

Review decisions and outcomes



From surgical observations to a collaborative training scenario

COURSE NOTES

A procedural model represents the sequence of actions, roles and events involved in a task. In team training, success depends on coordination rather than independent object manipulation. The virtual room supplies spatial organisation while the simulation represents dependencies among actions. Debriefing relates what happened, including communication and timing, to the intended learning objective.

The lecture uses a theatre rehearsal analogy: sequences and roles can be practised before all performance conditions are present. A team scenario supports practice of action order, handovers and responses to events. Debriefing then examines decisions and coordination. Success in the simulation still needs comparison with the intended real situation.

Trial records inform debriefing

1. **Goal**
   Choose a skill to practise
2. **Trial and records**
   Identify an omitted step or late handover
3. **Debriefing**
   Explain the decision and its effect
4. **Next trial**
   Adapt the scenario to the skill needing practice

COURSE NOTES

Measurements must serve the learning objective. In a team scenario, an omitted step or late handover can support discussion of a decision. Instructor and learner relate records to actions, then select the next trial. The theatre-rehearsal analogy illustrates practice before all real conditions are present. Records do not replace pedagogical interpretation.

A needle-insertion simulator

Required fidelity

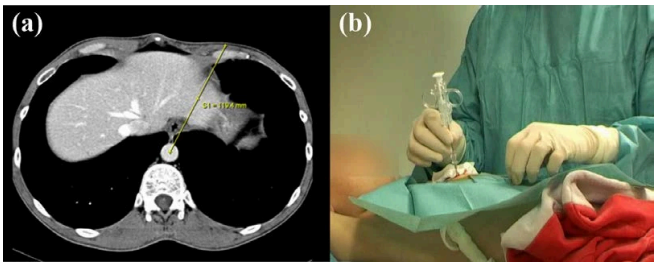
Tool path and tissue resistance

Useful modalities

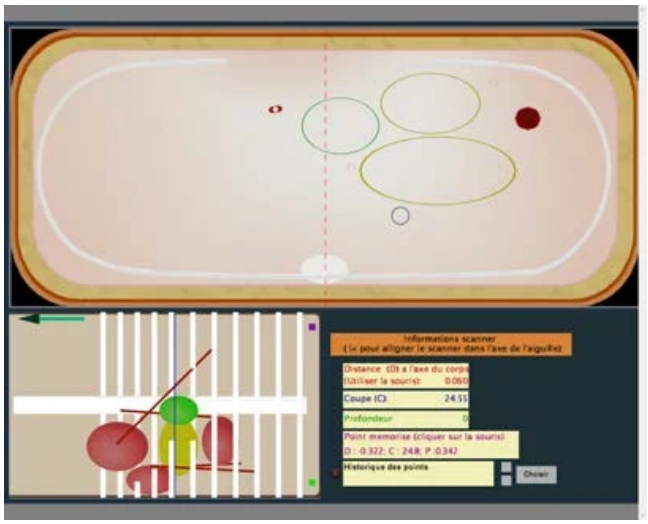
Vision and precise force feedback

Communication

A trainer may guide the learner



Needle-insertion training scenario



Tool and contact simulation

COURSE NOTES

A needle-insertion simulator illustrates task-dependent fidelity. The force felt during contact or penetration may carry information essential to the skill, while surrounding visual detail may contribute less. Training, remote instruction and actual teleoperation also impose different requirements for accuracy, delay and feedback. The appropriate interface follows from which part of the procedure the person needs to learn or control.

This example distinguishes understanding a task from finely adjusting a movement. A headset alone does not provide the resistance and contact required for every manual skill. The lecture discusses haptic interfaces and specialised simulators that align controls and feedback with a target task. Correspondence must be described for each device. A simulation demonstration alone does not establish skill transfer.

Lufthansa: VR in recurrent crew training

An existing workflow

Part of annual cabin-crew training

A repeated task

Search a virtual aircraft cabin

An operational constraint

Access without occupying a real aircraft

> Routine use answers “is it used?”; transfer testing answers “does it work?”

COURSE NOTES

Lufthansa Aviation Training describes VR hubs operating since 2019 and approximately 20,000 flight attendants completing part of their annual training in virtual cabins. The 2024 company video shows the wider XR training activity. Distinguish the established cabin-training workflow from new prototypes discussed in the film. This provider account documents use; it does not by itself establish comparative learning gains.

How is transfer assessed?

Test outside the simulator

Does the procedure or movement succeed on the target task?

Relevant comparison

Against which training and for which learners?

> The intended outcome determines the measurement.

Example: movement and force feedback ↗ Lufthansa demonstration ↗

COURSE NOTES

A simulator score is a proximal measure. Assess whether learning persists and transfers to the intended activity, preferably against an appropriate training alternative. Simulator fidelity should follow the skill: visual detail, forces and team communication have different importance for different tasks.

The oral discussion distinguishes understanding how to perform a task, learning a movement and adapting to a particular case. These goals need different assessments. Virtual preparation can precede real practice, but its contribution must be measured in that practice. The oral claim of faster subsequent real learning needs a specific study before being presented as a general result. For manual skills, evaluation should also examine errors and correspondence of sensory feedback.

Slide 20 / 91

Online slide ↗

Part 3 of 7

3.3
Healthcare and clinical uses

What is controlled and how is the person supported?

COURSE NOTES

A simulated situation can evoke emotion even when the participant knows that it is artificial. Research on phobias and post-traumatic stress uses this relationship within specified protocols. Interpretation depends on the population, exposure and outcome measure. An emotional reaction in a demonstration illustrates responsiveness to the scenario; it does not by itself establish a clinical benefit.

Slide 21 / 91

Online slide ↗

Clinical application · source examples

3.3 Healthcare and clinical uses

Which situation parameters can be controlled?

Scenario parameters

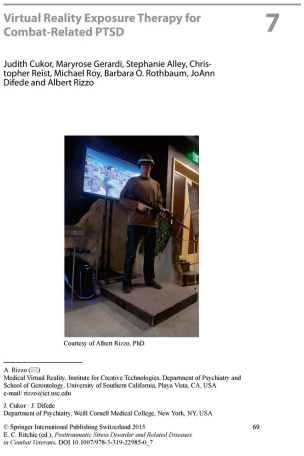
Crowd density, proximity, space size

Observations

Emotion and behaviour in the scene



A virtual height-related situation



Virtual Reality Exposure Therapy for Combat-Related PTSD 7

Judith Cukor, Maryrose Gerardi, Stephanie Alley, Christopher Reist, Michael Roy, Barbara O. Rothbaum, JoAnn Difede and Albert Rizzo

Courtesy of Albert Rizzo, PhD.

A. Rizzo (✉)
Medical Virtual Reality, Institute for Creative Technologies, Department of Psychiatry and School of Gerontology, University of Southern California, Playa Vista, CA, USA
e-mail: rizzo@ict.usc.edu

J. Cukor · J. Difede
Department of Psychiatry, Weill Cornell Medical College, New York, NY, USA

© Springer International Publishing Switzerland 2015
E. C. Ritchie (ed.), *Posttraumatic Stress Disorder and Related Diseases in Combat Veterans*, DOI 10.1007/978-3-319-22985-0_7

69

A historical exposure-therapy research example

> The scenario belongs to a defined intervention and assessment.

COURSE NOTES

A simulated situation can evoke emotion even when the participant knows that it is artificial. Research on phobias and post-traumatic stress uses this relationship within specified protocols. Interpretation depends on the population, exposure and outcome measure. An emotional reaction in a demonstration illustrates responsiveness to the scenario; it does not by itself establish a clinical benefit.

In the lecture's teaching example, the virtual environment offers adjustable parameters such as crowd density, space size or stimulus proximity. The scenario illustrates control and reproducibility of presented conditions. It provides neither a care protocol nor evidence for a particular indication. Use the example to identify controlled variables rather than prescribe a universal therapeutic progression.

What feedback accompanies movement?

Action

Perform a movement during the exercise

Visible feedback

Compare performed and intended movement

Measurement

Relate records to a functional objective

> Movement tracking and care follow-up answer different questions.

COURSE NOTES

Research on body perception includes altered body-size perception and virtual representations of missing limbs. These examples examine how sensory feedback can affect the representation of one’s body. A change in a perceptual measure is distinct from a broader therapeutic outcome. The interpretation depends on which experience was induced, what was measured and the conditions of the study.

The lecture develops distinct questions: supporting movement exercises, connecting action with visual body feedback and studying body perception. These should not be treated as a single clinical application. Phantom-limb and mirror examples recall the perception–action

relationship here. Mechanisms and therapeutic outcomes require specific references. Projects concerning body perception remain research questions without generalisation to a diagnosis or population.

Slide 23 / 91 Online slide ↗

3.3 Healthcare and clinical uses

How can remote follow-up be organised?

1. **Home exercise**
   Perform the planned activity
2. **Movement records**
   Make the session available for review
3. **Professional follow-up**
   Observe live or review the trial
4. **Feedback to the person**
   Adapt instructions for the next session

> Remote group rehabilitation: exercise with other patients in a shared virtual space.

COURSE NOTES

The classroom exchange describes home exercises with live observation or later review. A student account concerns a project after breast cancer; its setting and evaluation are not documented here. This slide describes a possible workflow without claiming device effectiveness. Group practice can be considered as a variant. The professional defines follow-up arrangements and feedback to the person.

Slide 24 / 91 Online slide ↗

FDA-cleared device · 2025 3.3 Healthcare and clinical uses

RelieVRx: a defined clinical indication

Who?

Adults with chronic lower back pain

What?

Prescription, home-based adjunctive treatment

How?

Immersive behavioural skills and exercises

> A clinical claim belongs to an intervention, population and outcome.

COURSE NOTES

The FDA cleared RelieVRx (Pico G3), K251519, on 13 August 2025. Its indication is adjunctive home treatment for adults with chronic lower back pain, using cognitive behavioural skills and other evidence-based behavioural methods. A specific device indication is narrower than a general claim that VR treats pain. Clearance, efficacy evidence for a defined intervention, and real-world clinical uptake are separate questions.

Healthcare: from mechanism to clinical use

Mechanism

Attention, graded exposure or feedback

Evaluation

Defined population, comparison and outcome

Care pathway

Indication, supervision and follow-up

COURSE NOTES

These are complementary steps, not a guarantee of progression. Laboratory changes in perception or emotion do not automatically establish clinical benefit. Discuss where evidence is needed for the particular rehabilitation, exposure or pain intervention under consideration.

A student describes a project supporting rehabilitation after breast cancer, with movement tracking and information sent to clinicians. This classroom account illustrates a possible workflow and is not a clinical evaluation. The lecture also discusses home exercises, live or later supervision and remote group practice. These examples raise questions about follow-up: who observes, when, and what feedback reaches the patient? The social dimension is a design direction discussed in class whose effects require evaluation.

3.4

Culture and entertainment

What does the experience offer its audience?

COURSE NOTES

Public applications range from entertainment to education and heritage interpretation. The learning or cultural purpose should guide interaction and content. Access to a reconstructed location does not remove uncertainty about the reconstruction. Distinguish documented evidence, interpretation and creative invention when presenting historical worlds.

Games and heritage: two reasons for immersion

Games

Act with the body; account for space and session length

Heritage

Explore a lost, remote or inaccessible place



Virtual environments for public experiences



Spatial exploration and learning

> The headset choice depends on the intended experience.

COURSE NOTES

Public applications range from entertainment to education and heritage interpretation. The learning or cultural purpose should guide interaction and content. Access to a reconstructed location does not remove uncertainty about the reconstruction. Distinguish documented evidence, interpretation and creative invention when presenting historical worlds.

The lecture asks how VR fits gaming habits: available space, effort, session length and interaction with people nearby. Scepticism about universal headset gaming is a position discussed in class rather than an established market forecast. Heritage offers a different argument: accessing and spatially exploring an absent, lost or inaccessible place. Distinguish a VR visit from tablet-based augmentation through the actual operation of the device.

Versailles: explore a vanished place

A shared visit

Free-roaming, multi-user VR

A reconstructed setting

Three lost spaces from the 1682 gardens

A public run

25 March 2025 – 4 January 2026



Royal Menagerie · © GEDEON / Small Creative / VIVE Arts / Versailles

COURSE NOTES

Lost Gardens of the Sun King was a public location-based experience at Versailles. Its reconstruction drew on archives, expert testimony and archaeological remains. The official exhibition dates establish an actual public presentation; the experience is presented here as a dated example rather than as a currently bookable visit. Ask how historical interpretation, shared movement and visitor mediation contribute to the experience.

Slide 29 / 91 Online slide ↗

Public experience · 2025–26 3.4 Culture and entertainment

Versailles: Lost Gardens — the VR experience

Versailles: Lost Gardens — the VR experience

Watch the video ↗

COURSE NOTES

Official Palace of Versailles video embedded in the museum magazine’s July 2025 article about the experience. Identify the role of reconstruction, interaction and shared exploration. This presentation of the public experience is not a measurement of learning outcomes.

Slide 30 / 91 Online slide ↗

3.4 Culture and entertainment

Culture: design the visitor journey

Content

What is explored or understood?

Participation

What can a visitor actually do?

Operation

Guidance, accessibility and visitor flow

Narrative and sensory perspectives ↗ Art and performance ↗ Public installations ↗

COURSE NOTES

Compare the narrative, artistic and heritage examples as complete visitor experiences. Their organisation includes the physical setting, mediation and access, as well as the virtual content. Select evaluation measures around the intended experience rather than importing a training metric.

Slide 31 / 91

Online slide ↗

Part 5 of 7

3.5
Social virtual reality

Which activities do people share in VR?

COURSE NOTES

Which activities do people share in VR?

Slide 32 / 91

Online slide ↗

Cultural / public example

3.5 Social virtual reality

Which activities do people share in VR?

Meet

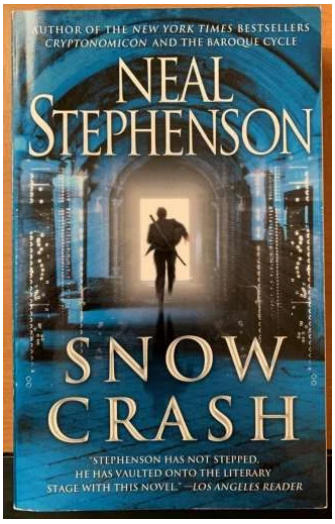
Converse in a shared virtual place

Create and participate

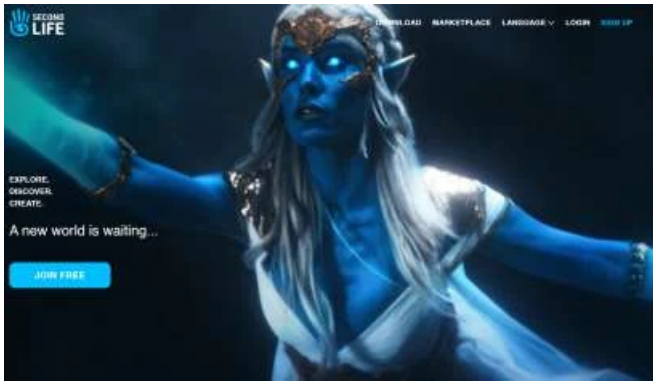
Play, learn or join a performance

Represent oneself

Act through an avatar and its gestures



Snow Crash



Second Life: a historical social-world example

> The shared activity gives social VR its purpose.

COURSE NOTES

Social virtual worlds organise interaction between people through spatial content and representations of participants. The metaverse idea, associated with Snow Crash, adds broader expectations about persistence, identity and connections between services. VR, social worlds and these narratives overlap without being equivalent. Headset use, interoperability, content governance and persistent identity are separate properties of a platform.

The discussion distinguishes promises of general adoption from practices in particular communities. The lecturer describes an investigation with an anthropologist involving VRChat users. In the interviews discussed, virtual activities extend artistic and social activities carried out elsewhere. This account invites examination of continuity between practices rather than an assumption of social isolation. Profiles and usage totals mentioned orally cannot characterise all users; the study reference and methods remain to be documented.

How can other people be made present?

Voice and gesture

Identify who is speaking and acting

Space and objects

Understand what is shared

Avatar

Express identity and intention

Place rules

Organise access and coexistence

COURSE NOTES

Social VR connects people in a shared virtual space, whether physically nearby or remote. Voice, gesture and position cues communicate aspects of their actions. Representations should help participants understand who is speaking, what another person is attending to and which object they are acting on. Avatars offer expression; access and moderation rules organise coexistence. Examine a shared scene through the activities it supports.

VRChat: continuity of social practices

Investigation discussed in class · Privateer, Peillard and Loetscher, 2025

Activities

Extend an artistic or social practice

Places and identities

Choose a setting and representation

Research question

How do these practices connect in everyday life?

> Examples reported in class; distinguish the inquiry’s scope from all users’ practices.

Conference contribution ↗

COURSE NOTES

The lecture describes an investigation with Lilas Privateer about VRChat use. DJ and artist examples illustrate possible continuity between physical and virtual activities through different places and representations. Privateer, Peillard and Loetscher’s 2025 11ICSSM contribution, Embodied Interaction and Habituation in Virtual Reality: A Digital Anthropological Inquiry, is listed on the lecturer’s website and the CROSSING publications page. The full text could not be consulted during this revision. Observations are attributed to the classroom account without a sample size, detailed method or generalisation to all users.

Social VR: which activity, with whom?

Situation

Who meets, and for which activity?

Contribution to examine

What do shared space and avatars enable?

Social-world archives ↗ Shared learning ↗ Telepresence research ↗

COURSE NOTES

The social family covers meetings and common activities whose purpose depends on relationships between people. It overlaps collaborative training, group visits and group rehabilitation without being reducible to these domains. Evaluate a proposal by describing what people do together, the cues available and access constraints. A study of practices requires a defined field and participants.

Slide 36 / 91

Online slide ↗

Part 6 of 7

3.6

Choosing and evaluating a use

Which activity justifies choosing VR?

COURSE NOTES

This comparison distinguishes types of claims. A recorded prototype, an operational workflow, a clinical indication and a public exhibition each support a different conclusion. Choose a suitable baseline and measurement before claiming benefit.

Slide 37 / 91

Online slide ↗

3.6 Choosing and evaluating a use

Compare evidence, not impressions

Family	Object of comparison	Possible criteria
Industry	Design decision	Errors and effort
Training	Transfer to the real task	Omissions and accuracy
Healthcare	Defined intervention and population	Target outcome and follow-up
Culture	Visitor journey	Experience and understanding
Social VR	Activity and participants	Coordination and shared experience

COURSE NOTES

The five families need criteria connected to the activity’s purpose. This table proposes assessment targets rather than reporting measured outcomes. Choose a reference situation and specify what the simulation represents. Research studies and demonstrations follow in the further examples.

A building model: why choose VR?

Discussion case: you have a 3D model of a building.

Activity

Which task and which people?

Expected contribution

What does immersive exploration enable?

Limit

Which information or constraint is missing?

Comparison

How would you assess it against another solution?

COURSE NOTES

Choosing VR requires identifying what the activity gains from spatial perception, bodily action or a shared simulated situation. A desktop interface or a physical prototype may be sufficient when those properties add little. The decision can be evaluated through an observable success criterion, a suitable comparison and a description of what the simulation omits. The value lies in the supported activity rather than the device alone.

Revisit an opening example. The same model could support circulation checks, procedure preparation, a visit or a remote meeting. Ask for an answer justified by context and a comparison with a screen-based visit or physical model.

From applications to system design

Start with the activity

Users, setting and intended outcome

Specify the interaction

Cues, actions and shared state

Select the evidence

Baseline, measurement and deployment context

Further examples and research ↗ Return to the five families ↗

COURSE NOTES

Scientific work connects a result to a question, a method and conditions of observation. A demonstration shows a possibility; a study compares conditions and measures their effects. The scope of a conclusion depends on that distinction and on the limits of the evaluation.

Slide 40 / 91

Online slide ↗

Part 7 of 7

3.7

Further examples and research

Additional demonstrations and open questions

COURSE NOTES

Organise the research examples by the question they allow us to investigate. Controlled studies, collaborative prototypes and tangible-computing explorations produce different kinds of evidence. The demonstrations that follow retain their original research context.

Slide 41 / 91

Online slide ↗

3.7 Further examples and research

Resources for exploring each family

Additional demonstrations

Consult an example for the question being studied

Research

Observe, coordinate and explore new interfaces

Design and industry ↗ Training and skills ↗ Healthcare and clinical uses ↗ Culture and entertainment ↗

Social virtual reality ↗ Research questions ↗ Family map ↗

COURSE NOTES

The main route is complete. Links lead to retained additional demonstrations and research questions. Historical demonstrators retain their status and references. Return to the map to resume the main route.

Industrial design demonstration

What is physically touched? What is simulated?



Industrial design demonstration

Watch the video ↗

> A physical support can complement a virtual model.

COURSE NOTES

Virtual prototypes allow design questions before a physical prototype exists. The examples include product appearance, seat insertion, manufacturing processes and workstation ergonomics. Fidelity must support the question being asked: correct dimensions and reach may matter more than surface appearance. A model can omit physical constraints unless those constraints are explicitly simulated.

Read the demonstration through the physical components retained, such as a steering wheel, seat or dashboard section. A product-specific installation can combine physical supports with alternative virtual designs. Distinguishing actual contact from simulated appearance helps establish what the test can assess.

Interior and HMI simulation: Modelisar



Interior and HMI simulation: Modelisar

Watch the video ↗

COURSE NOTES

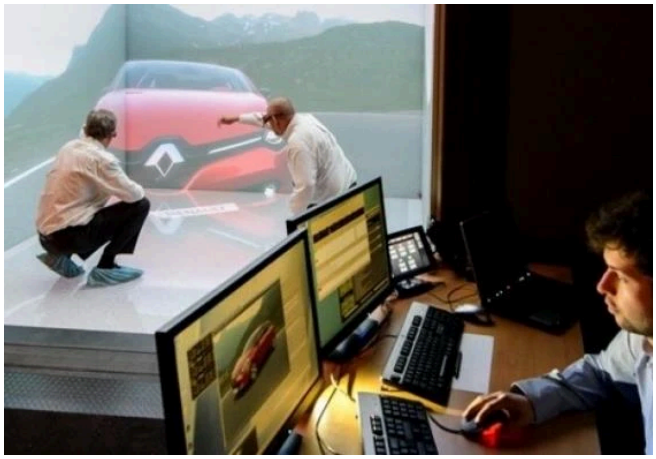
The Modelisar demonstration combines an interior and human–machine interface design with simulation. Identify which behaviours are simulated and how the shared 3D context supports a design decision. This is an archival demonstration, distinct from the current industrial workflow examples that follow.

Airflow inside a vehicle connects design with scientific visualisation. A simulation produces spatial data that can be inspected from different viewpoints around the product. The task is to understand where a flow travels and how it occupies the volume. Interpretation also depends on representations, cross-sections and interaction tools.

Industrial design: complementary views



Immersive design review



Product design in context



A digital human in an assembly task

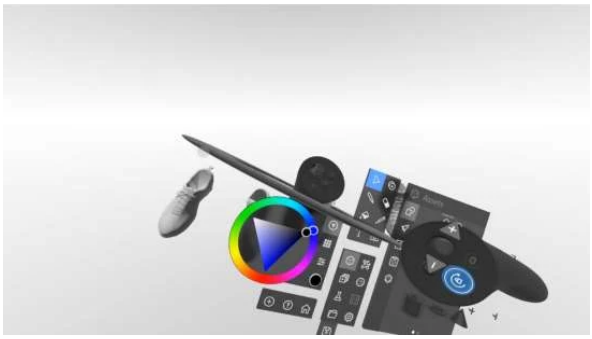
> Which dimensions must be faithful for the decision?

COURSE NOTES

Shape review, human reach and assembly planning require different information from the same model. A view that makes a surface easy to inspect may not reveal whether a person can reach a component or perform an assembly step. The simulation must represent the geometry and constraints relevant to the decision. Fidelity is therefore judged relative to the industrial question, not only to visual appearance.

Spatial authoring interfaces

Microsoft Maquette



Microsoft Maquette: spatial prototyping (archive)

Watch the video ↗

Prototype a space and its interfaces

Gravity Sketch



Gravity Sketch: collaboration around a model

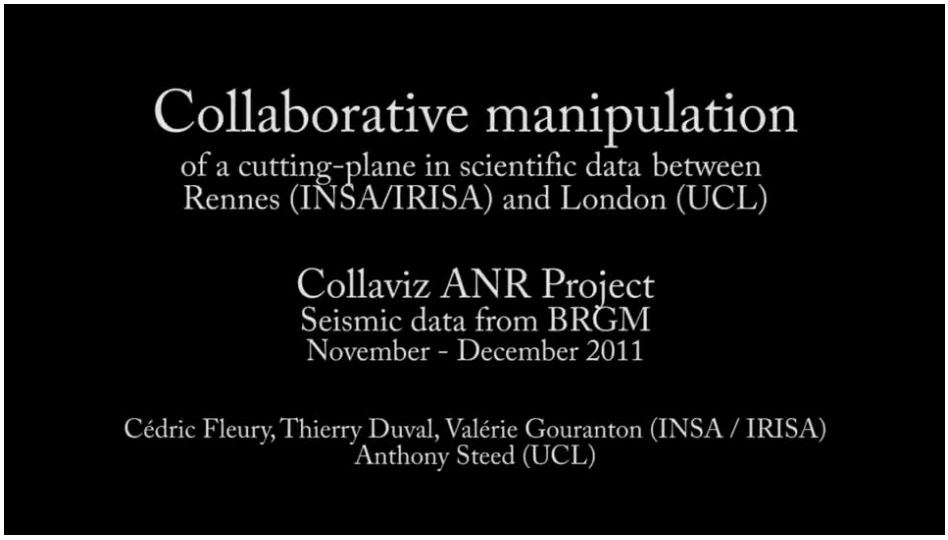
Watch the video ↗

Create and share a 3D model

COURSE NOTES

Maquette illustrates spatial and interface prototyping, while Gravity Sketch illustrates modelling and shared design review. Creating geometry, arranging a scene and defining its behaviour are separate operations. A spatial modelling tool does not automatically provide an application’s interaction logic. The difference between these activities explains why authoring systems need both direct manipulation and structured controls.

Collaborative exploration of scientific data



Collaborative exploration of scientific data

Watch the video ↗

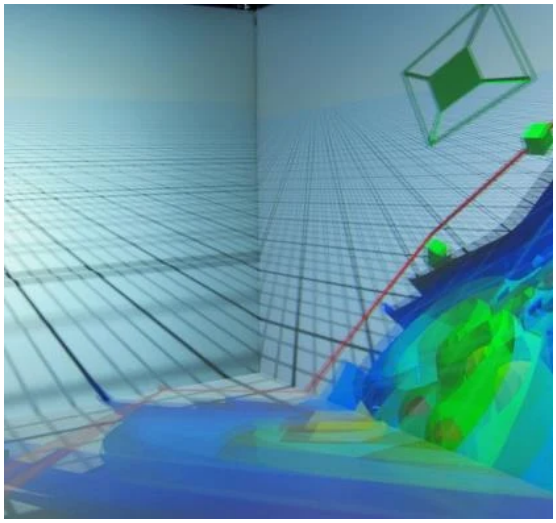
COURSE NOTES

The examples include flow, temperature and scientific structures. Spatial viewing can help reveal relationships, but a 3D display is not automatically the clearest way to answer every data question. Discuss the role of abstraction, comparison, colour and task-specific interaction. These are historical demonstration clips, not claims about current products.

Scientific data in a spatial setting



Scientific visualisation example

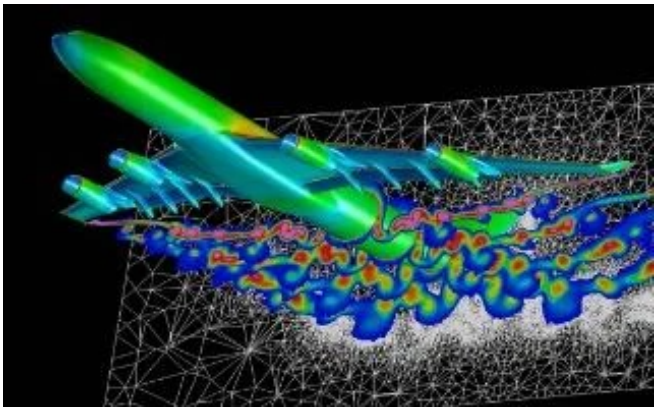


A spatial data representation

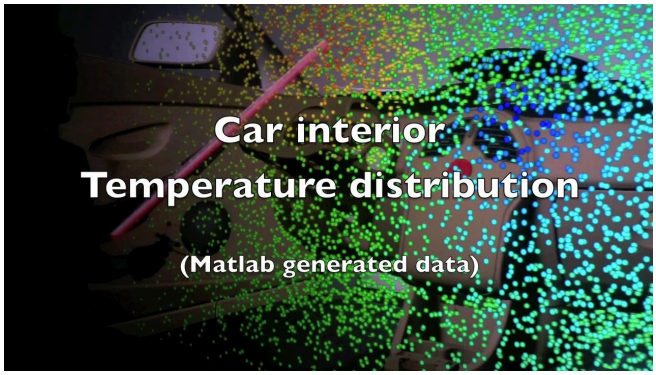
COURSE NOTES

Surface geometry, field data and the observer’s position contribute different information. Colour may encode a measured quantity, whereas shape and spatial scale describe a structure. An immersive view can reveal relationships, but interpreting the data still requires a clear legend, meaningful units and a task. Moving around a representation is useful when it answers a question that a fixed view leaves ambiguous.

Interactive inspection and thermal data



Interactive inspection



Temperature distribution in a vehicle

> What information does spatial viewing add?

COURSE NOTES

Surface geometry, field data and the observer’s position contribute different information. Colour may encode a measured quantity, whereas shape and spatial scale describe a structure. An immersive view can reveal relationships, but interpreting the data still requires a clear legend, meaningful units and a task. Moving around a representation is useful when it answers a question that a fixed view leaves ambiguous.

Rivian: review a vehicle inside the headset

A life-size model

Review proportions, surfaces and the interior

A shared decision

Bring design and engineering into the same scene

An iterative workflow

Change the digital model before physical mock-ups



Rivian: the VR design workflow — Autodesk

Watch the video ↗

COURSE NOTES

Rivian’s immersive design reviews place a digital vehicle model within a professional decision process. Inspecting form, interior layout and the relation to a physical mock-up can support different design questions. Autodesk’s 2023 demonstration illustrates that workflow; the higher-fidelity XR configuration presented in 2025 is a separate technical development. Reported productivity benefits remain customer and supplier accounts rather than independent controlled measurements.

BMW Virtual Factory: the industrial workflow

BMW Virtual Factory: the industrial workflow

Watch the video ↗

COURSE NOTES

Official BMW Group footage, June 2025. Identify the data, simulated operations and decisions being supported. Discuss which operations benefit from immersion and which run without a headset.

A shared surgical simulation

Task

Coordinate a procedure

Interfaces

Vision, communication and contact

Evaluation

Accuracy, cooperation and comfort



Collaborative surgical training

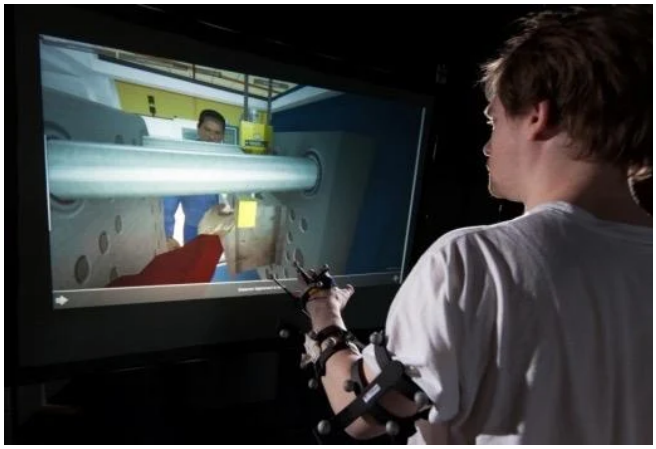
COURSE NOTES

A collaborative surgical simulation represents a procedure performed by several people. Roles, procedural steps and tool contacts organise the activity; vision, communication and sometimes force feedback support coordination. A convincing scene is only one part of training. Effectiveness depends on accuracy, coordination and the transfer of skills to the target activity.

Training contexts



A set of professional training contexts



A procedural training example



A simulated work situation

> What is practised, and how would learning be assessed?

COURSE NOTES

A training environment is defined by the skill being practised, the feedback available and the conditions of assessment. Repeating a procedure can improve performance inside the simulator without guaranteeing transfer to the real activity. Evaluation therefore concerns what is learned, whether it persists and whether it can be used under the conditions for which training was designed.

Lufthansa: extended reality crew training

Lufthansa: extended reality crew training

Watch the video ↗

COURSE NOTES

Official Lufthansa Group Inside Sessions, published September 2024. Identify the trained skill, the feedback and the distinction between a current training workflow and an experimental extension.

3.7 Further examples and research

How can body perception be studied?

Manipulation

Change a virtual-body property

Observation

Measure a defined perceptual response

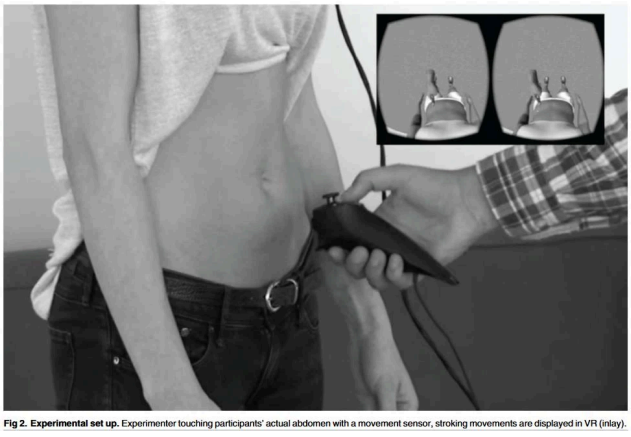


Fig 2. Experimental set up. Experimenter touching participants' actual abdomen with a movement sensor, stroking movements are displayed in VR (inlay).

A body-perception research setup

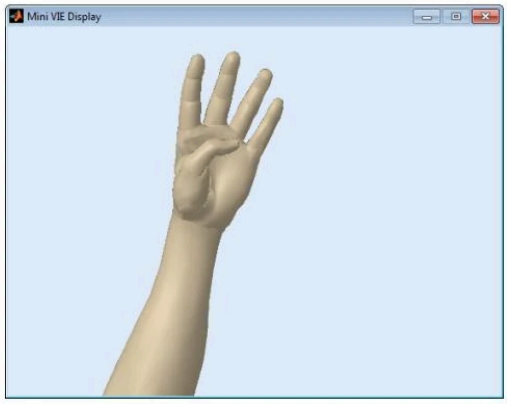


Figure. 2. A snapshot of a motion prompt within the VIE framework, here asking the subject to move the thumb of his phantom limb.

A virtual limb controlled through physiological input

COURSE NOTES

Virtual-body modifications address a perceptual question. Describe the manipulation, feedback and measured response before discussing applications. Mirror and virtual-limb examples in the lecture connect action with perception. Alone, they establish neither a general pain mechanism nor a clinical conclusion. Figures come from the source material on embodiment.

Cultural / public example

3.7 Further examples and research

Narrative and sensory perspective

Notes on Blindness

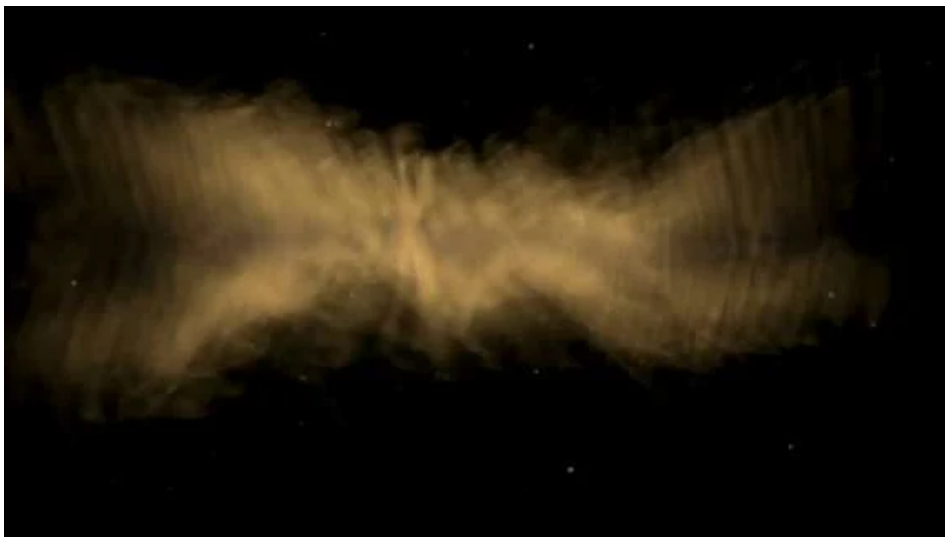
A world organised through sound

Carne y Arena

An embodied spatial encounter

Traveling While Black

A situated narrative experience



Notes on Blindness VR: IDFA trailer

Watch the video ↗

COURSE NOTES

Notes on Blindness uses sound and spatial representation to organise access to a narrated experience. The shapes that become perceptible are related to the sonic environment, rather than simply providing a conventional visual scene. This artistic choice makes sensory perspective part of the storytelling. Encountering that perspective through a device remains distinct from reproducing another person's life or entire perceptual experience.

Art, performance and virtual identity



Christophe Viart: Assemblée générale



Spectre: an immersive performance setting

COURSE NOTES

The examples combine fiction, installations and live performance. The fictional examples are cultural references rather than technical evidence. Assemblée générale and Spectre invite discussion of representation, shared space and the boundary between performer and participant. Compare recorded presence, live interaction and an interactive avatar.

Gender Swap and mediated perspective

Representation

A different visible body

Correspondence

Movement and viewpoint relation

Interpretation

Experience and its limits



Gender Swap — BeAnotherLab

Watch the video ↗

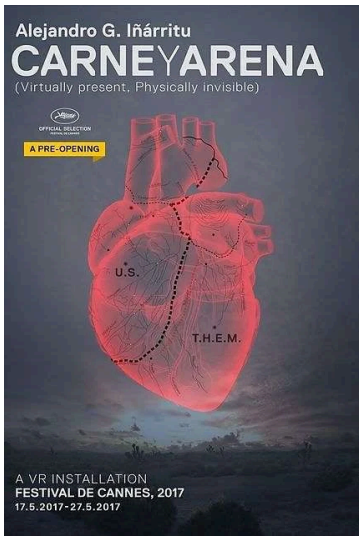
COURSE NOTES

Gender Swap uses cameras, headsets and synchronised movements to alter the visual relationship between a participant and another person’s body. The arrangement raises questions about viewpoint and bodily identification. The artistic experience does not literally

transfer an identity, and its documentation alone cannot establish a lasting change in empathy. Viewpoint, sensory correspondence and the participant's reports describe different aspects of the experience.

Mediated experience and identity

Carne y Arena



Carne y Arena — ILMxLAB

Watch the video ↗

Spatial installation: trailer

Traveling While Black



Traveling While Black — New York Times Op-Docs / Félix & Paul Studios

Watch the video ↗

360° documentary: excerpt

> How does each work place the participant within its subject?

COURSE NOTES

Carne y Arena and Traveling While Black organise situated experiences through viewpoint, sound, narrative and bodily participation. The first documents an immersive installation, while the second uses a filmed environment to situate testimony. An embodied installation and a recorded spherical film offer different ways of encountering a story. Their expressive force depends on that arrangement, not simply on the presence of a headset.

Exhibitions and public space

Care / Cure

Architecture and an exhibition context

Débord de Loire

An event in a shared public setting

Immersive design

Content, physical access and mediation



Care / Cure exhibition



Débord de Loire public event

COURSE NOTES

The closing examples in Frontiers of the Virtual frame possible design projects in exhibitions, heritage sites and public events. Their 2022 calls and schedules are historical context, not current opportunities. Reuse the design questions: how does an installation fit its setting, what does the audience do, and what traces of the experience remain?

Public installations and their setting



Exhibition space



A public event on the Loire

COURSE NOTES

An immersive installation includes the physical place in which it is encountered. Access, audience circulation, instructions and mediation shape how the virtual content can be understood. A representation associated with a specific site also connects digital interpretation with material traces. The visitor’s experience therefore includes the approach to the installation, participation and the return to the surrounding place.

History and heritage settings



A historical project setting



A heritage project setting

> The physical venue remains part of the experience

COURSE NOTES

An immersive installation includes the physical place in which it is encountered. Access, audience circulation, instructions and mediation shape how the virtual content can be understood. A representation associated with a specific site also connects digital interpretation with material traces. The visitor’s experience therefore includes the approach to the installation, participation and the return to the surrounding place.

Perceptual stages and projected environments



A staged environment and its physical construction



A visually transformed room

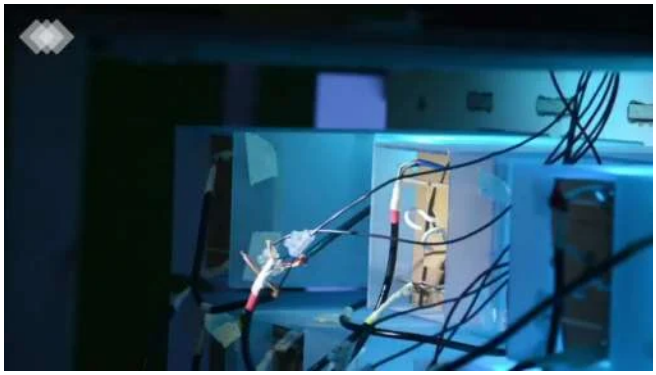
COURSE NOTES

Projection, lighting and built surfaces can change the apparent shape or depth of a stage without changing its entire physical structure. The effect depends on the relation between the projected image and the observer’s viewpoint. An interactive installation adds a further relationship: participant actions can alter what is projected. Physical transformation, visual illusion and responsiveness are distinct properties.

Projection and spatial illusion



Projection changes the apparent space



Performance and spatial illusion

COURSE NOTES

Projection, lighting and built surfaces can change the apparent shape or depth of a stage without changing its entire physical structure. The effect depends on the relation between the projected image and the observer’s viewpoint. An interactive installation adds a further relationship: participant actions can alter what is projected. Physical transformation, visual illusion and responsiveness are distinct properties.

Designing an immersive installation

Display geometry

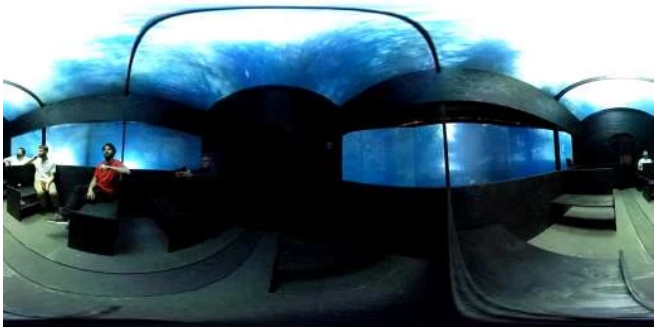
Coverage, seams and viewpoint

Audience

Individual or collective experience

Physical setting

Movement and access



Immersive installation prototypes



Projected content in a collective installation

COURSE NOTES

Designing an immersive environment includes its architecture and the organisation of experience. A system can surround a group without providing each person with geometrically correct stereo imagery. Analyse what the display promises, what tracking supports and how participants move through the installation.

Marketing and product experience

Showrooms

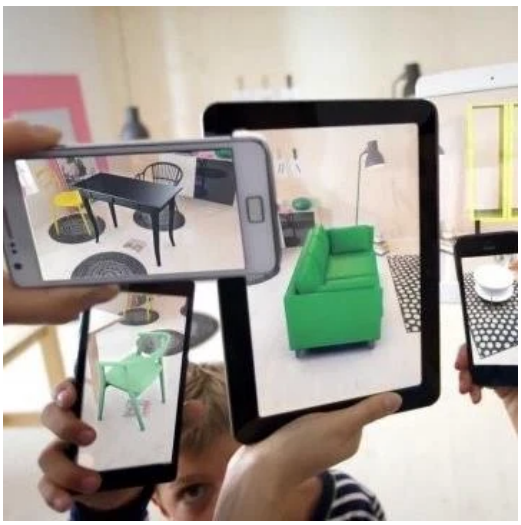
Explore configurations and scale

Demonstrations

Experience a proposed service

Assessment

Separate persuasion from task performance



A product demonstration context



A virtual showroom

COURSE NOTES

Virtual showrooms can make products or configurations available without transporting every physical object. Marketing value does not imply improved understanding or better decisions. Ask which attributes the simulation represents faithfully and which are absent, such as material feel, weight or lighting conditions.

Social virtual places: a historical comparison



A shared virtual meeting space



Meta Horizon Worlds: historical promotional film

Watch the video ↗

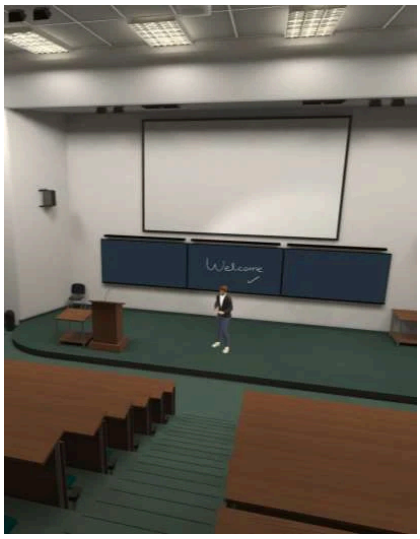
COURSE NOTES

Spatial and Meta Horizon Worlds illustrate different ways of representing shared virtual places. The visible arrangements raise questions about avatar expression, the organisation of space and the activities people perform together. Promotional scenes show an intended experience rather than measured usability. The comparison concerns the represented forms of social activity, not whether each service is currently available.

Shared learning and web environments



A web-based shared environment



ENGAGE XR: educational environments

Watch the video ↗

What can participants share besides conversation?

COURSE NOTES

ENGAGE illustrates a virtual space organised for educational and collaborative activities. Mozilla Hubs illustrates another arrangement of avatars, spatial content and access to a shared room. Their comparison concerns what participants can perceive and do together. A demonstration of an educational platform does not by itself measure learning; that requires an activity, an assessment and a comparison condition.

Three research lenses

Observe people

Control worlds and measure responses

Coordinate people

Study shared space and remote action

Reconfigure interaction

Explore tangible and multisensory interfaces

COURSE NOTES

Organise the research examples by the question they allow us to investigate. Controlled studies, collaborative prototypes and tangible-computing explorations produce different kinds of evidence. The demonstrations that follow retain their original research context.

VR as an experimental setting

Control

Manipulate the environment

Observation

Record actions and responses

Validity

Check the relation to the target situation



Controlled situations in virtual environments

COURSE NOTES

VR supports experimental control over spatial, social and sensory conditions. It also introduces device-related constraints and possible discomfort. Presence can inform interpretation, but it does not by itself establish ecological or psychological validity. The experiment must connect the virtual task with the behaviour or mechanism under study.

Shared touch: studying social perception

Manipulation

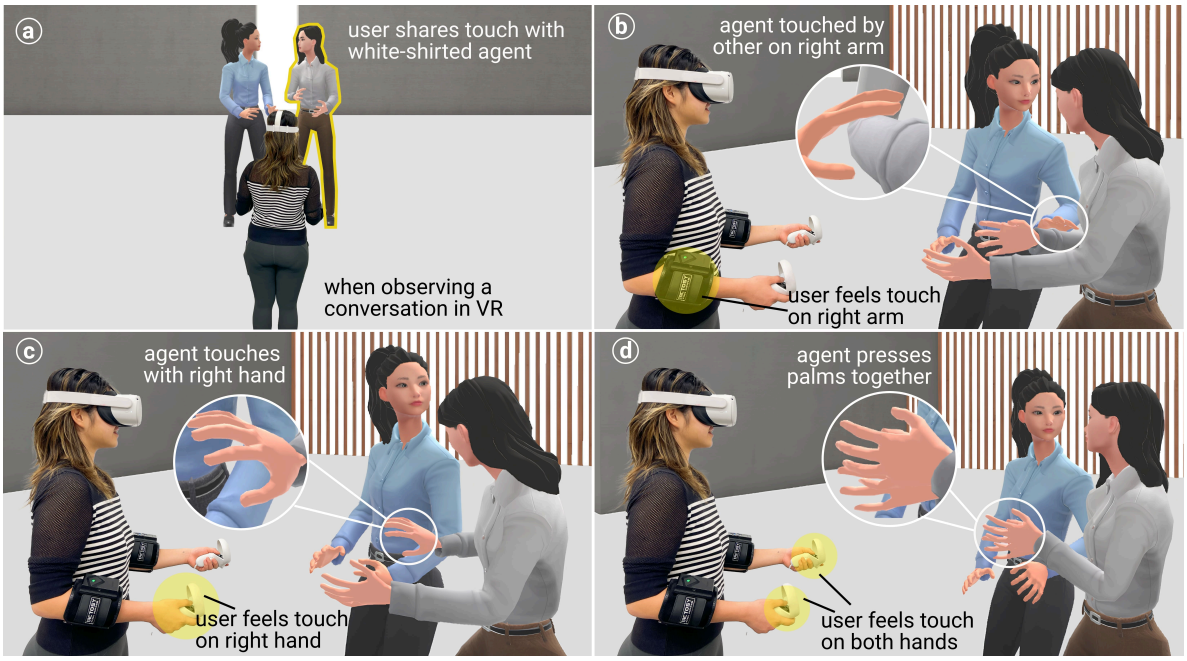
Feel touch while observing a virtual agent

Study

Within-participant experiment · n = 32

Question

How does shared sensation affect social response?



Tao, Egelman & Bailenson · ISMAR 2024 · Figure 1

COURSE NOTES

In the 2024 I Feel You study, participants observed virtual agents and received corresponding touch sensations. Participants reported changes in body illusion and empathy, and changed interpersonal distance under the tested conditions. This is a controlled finding about social perception, not evidence of a deployed therapy or collaboration product. The figure illustrates the experimental technique.

Research lens: coordinate shared action

Representation

How are people and actions made visible?

Shared space

Which viewpoints and objects are common?

Coordination

How do people divide and combine control?

COURSE NOTES

Read the following collaboration demonstrations through these three recurring research questions. Their technical capability can be observed in a video, while performance or social effects require a study appropriate to the task.

Collaborative virtual environments

Shared state

Participants affect a common world

Communication

Voice, gesture and spatial cues

Coordination

Awareness of others and their actions



Collaborative industrial work

COURSE NOTES

A collaborative virtual environment combines human–computer and human–human interaction. Participants may be physically co-located or remote. The shared state must remain coherent enough for coordination, and users need cues about what others can see and do. A common digital room alone is insufficient for effective cooperation.

Telepresence

Remote people

Represented in a shared environment

Spatial communication

Pose, gaze and gestures

A shared task

An activity beyond conversation



Telepresence demonstration

COURSE NOTES

Telepresence can support communication around shared spatial content. Representations range from simple markers to reconstructed people. Their appearance, motion and delay can influence coordination and social experience. A recorded demo demonstrates a capability in its original context, not a guarantee for arbitrary users or network conditions.

Telepresence archive



Telepresence archive

Watch the video ↗

COURSE NOTES

Telepresence can support communication around shared spatial content. Representations range from simple markers to reconstructed people. Their appearance, motion and delay can influence coordination and social experience. A recorded demo demonstrates a capability in its original context, not a guarantee for arbitrary users or network conditions.

Sharing a projection room

Viewpoint

Several independently moving observers

Display

Separate view channels where supported

Coordination

Physical and virtual workspace

COURSE NOTES

These demonstrations compare multi-viewer display arrangements and co-habitation in a CAVE. The Chen et al. (2015) example concerns shared use of an immersive space. Distinguish correct rendering for several viewpoints from awareness and coordination between participants. The specialised demonstrations do not describe the capabilities of every CAVE.

Multiple-viewer projection



Multiple-viewer projection

Watch the video ↗

COURSE NOTES

These demonstrations compare multi-viewer display arrangements and co-habitation in a CAVE. The Chen et al. (2015) example concerns shared use of an immersive space. Distinguish correct rendering for several viewpoints from awareness and coordination between participants. The specialised demonstrations do not describe the capabilities of every CAVE.

Co-habitation in a CAVE



Co-habitation in a CAVE

Watch the video ↗

COURSE NOTES

These demonstrations compare multi-viewer display arrangements and co-habitation in a CAVE. The Chen et al. (2015) example concerns shared use of an immersive space. Distinguish correct rendering for several viewpoints from awareness and coordination between participants. The specialised demonstrations do not describe the capabilities of every CAVE.

Co-located object manipulation

Physical support

A shared tangible relation

Virtual action

A common object or activity

Coordination

Who controls each part?

COURSE NOTES

Aguerreche and colleagues’ co-located manipulation example links physical support with the digital representation of a shared object. Each participant’s control affects the common task. Visual feedback, mechanical constraints and communication contribute different information about the other person’s actions. Cooperation depends on understanding both the state of the object and the relationship between participants’ inputs.

Co-located manipulation



Co-located manipulation

Watch the video ↗

COURSE NOTES

Aguerreche and colleagues’ co-located manipulation example links physical support with the digital representation of a shared object. Each participant’s control affects the common task. Visual feedback, mechanical constraints and communication contribute different information about the other person’s actions. Cooperation depends on understanding both the state of the object and the relationship between participants’ inputs.

Physical co-presence and virtual activity

Physical space

Participants occupy a common room

Virtual context

The displayed activities may differ

Interaction

Bodies can become part of another person’s constraints

COURSE NOTES

Cheng and colleagues’ example of unintended collaboration examines how sharing a physical setting can connect activities that appear separate in the virtual world. A person can influence another’s movement or access to space without that relationship being explicit in the virtual task. Physical co-presence and virtual co-presence therefore need separate descriptions when designing a shared installation.

Shared-space interaction research



Shared-space interaction research

Watch the video ↗

COURSE NOTES

Cheng and colleagues' example of unintended collaboration examines how sharing a physical setting can connect activities that appear separate in the virtual world. A person can influence another's movement or access to space without that relationship being explicit in the virtual task. Physical co-presence and virtual co-presence therefore need separate descriptions when designing a shared installation.

Remote collaboration and group telepresence

Shared state

Objects, tools and participant actions

Representation

Simplified avatars or captured people

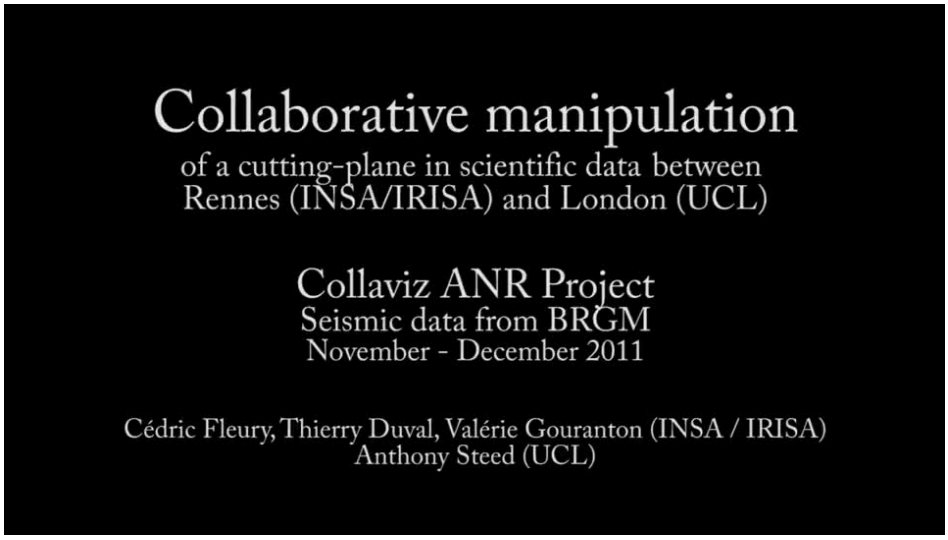
Group activity

Coordination across sites

COURSE NOTES

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.

Fleury et al. (VRST 2012)



Fleury et al. (VRST 2012)

Watch the video ↗

COURSE NOTES

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.

Beck et al. (IEEE VR 2013)



Beck et al. (IEEE VR 2013)

Watch the video ↗

COURSE NOTES

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.

Research lens: reconfigure the interface

Physical objects

Arrange and manipulate information

The body

Move around a shared workspace

Computation

Make relationships visible and executable

COURSE NOTES

Dynamicland extends the discussion beyond headset VR. It is a research context for shared physical computation, useful for comparing paradigms of spatial interaction. It should not be described as an industrial VR deployment.

Dynamicland: shared physical computation

Physical objects

Manipulable parts of an activity

Projection

Digital information in the workspace

Collaboration

People work around a shared setting

COURSE NOTES

Dynamicland distributes computation through a shared physical workspace. People manipulate objects and documents while digital behaviour is associated with their arrangement. The physical setting remains available to several participants, including people who are not directly operating a device. This is a useful contrast with a headset environment: shared computation does not require replacing the visible physical world.

Dynamicland archive



Dynamicland archive

Watch the video ↗

COURSE NOTES

Dynamicland distributes computation through a shared physical workspace. People manipulate objects and documents while digital behaviour is associated with their arrangement. The physical setting remains available to several participants, including people who are not directly operating a device. This is a useful contrast with a headset environment: shared computation does not require replacing the visible physical world.

Computing with objects and the body

Arrange

Objects become part of a computation

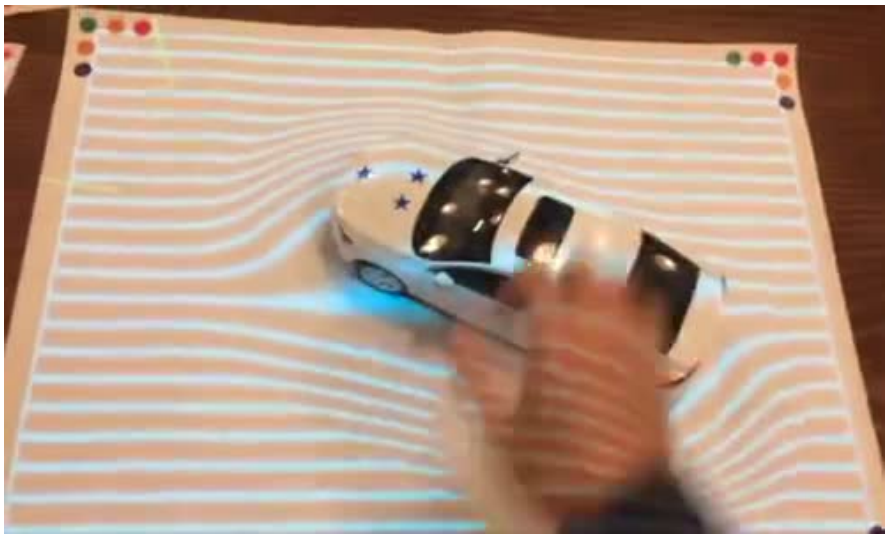
Move and compare

The body participates in the activity

COURSE NOTES

Tangible interaction uses the shape, position and movement of physical objects as part of a digital interface. Handling an object provides contact and mechanical constraints, while its visible position can communicate the state of the activity to other people. The design question is which properties remain physical and which are simulated. Shared access also changes how participants coordinate and understand one another's actions.

Dynamicland: example 1



Dynamicland: example 1

Watch the video ↗

COURSE NOTES

Tangible interaction uses the shape, position and movement of physical objects as part of a digital interface. Handling an object provides contact and mechanical constraints, while its visible position can communicate the state of the activity to other people. The design question is which properties remain physical and which are simulated. Shared access also changes how participants coordinate and understand one another's actions.

Dynamicland: example 2



Dynamicland: example 2

Watch the video ↗

COURSE NOTES

Tangible interaction uses the shape, position and movement of physical objects as part of a digital interface. Handling an object provides contact and mechanical constraints, while its visible position can communicate the state of the activity to other people. The design question is which properties remain physical and which are simulated. Shared access also changes how participants coordinate and understand one another’s actions.

Dynamicland: example 3



Dynamicland: example 3

Watch the video ↗

COURSE NOTES

Tangible interaction uses the shape, position and movement of physical objects as part of a digital interface. Handling an object provides contact and mechanical constraints, while its visible position can communicate the state of the activity to other people. The design question is which properties remain physical and which are simulated. Shared access also changes how participants coordinate and understand one another’s actions.