# Navigation Interfaces for Virtual Reality and Gaming: Theory and Practice

**Ernst Kruijff**
Institute of Visual Computing
Bonn-Rhein-Sieg University of
Applied Sciences
Sankt Augustin, 53757, Germany
ernst.kruijff@h-brs.de

**Bernhard E. Riecke**
School of Interactive Arts and
Technology
Simon Fraser University
Surrey, V3T 0A3, Canada
ber1@sfu.ca


*CHI'18 Extended Abstracts, April 21–26, 2018, Montréal, QC, Canada*

ACM ISBN 978-1-4503-5621-3/18/04.
https://doi.org/10.1145/3170427.3170643

## Abstract
In this course, we will take a detailed look at various breeds of spatial navigation interfaces that allow for locomotion in digital 3D environments such as games, virtual environments or even the exploration of abstract data sets. We will closely look into the basics of navigation, unravelling the psychophysics (including wayfinding) and actual locomotion (travel) aspects. The theoretical foundations form the basis for the practical skillset we will develop, by providing an in-depth discussion of navigation devices and techniques, and a step-by-step discussion of multiple real-world case studies. Doing so, we will cover the full range of navigation techniques from handheld to full-body, highly engaging and partly unconventional methods and tackle spatial navigation with hands-on-experience and tips for design and validation of novel interfaces. In particular, we will be looking at affordable setups and ways to "trick" out users to enable a realistic feeling of self-motion in the explored environments. As such, the course unites the theory and practice of spatial navigation, serving as entry point to understand and improve upon currently existing methods for the application domain at hand.

## Author Keywords
Navigation; immersive systems; interface design; human factors.

## ACM Classification Keywords
H.5.1. Information Interfaces and Presentation: Artificial, augmented, and virtual realities; H.5.2.

Information interfaces and presentation: User Interfaces

## Benefits

By participating in two consecutive and logically interlinked sessions, participants will acquire necessary skill set to design, develop and validate navigation techniques and interfaces for virtual reality and gaming systems. Sessions are logical blocks that can also be attended individually, allowing for a certain level of flexibility for CHI attendees, yet full participation is recommended. In summary, the sessions will enable participants to acquire the necessary knowledge and skills through following topics:

**Theory**: The fundamental basics of spatial navigation and applicable usage domains will be presented. Following, a classification of different navigation interfaces and techniques (with pros and cons) as well as adverse effects such as motion sickness and usability issues will be discussed, along with a set of guidelines.

**Practice**: Methodologies to design, develop, and validate novel navigation techniques and interfaces will be presented, again accompanied with a set of guidelines. Following, participants will be guided through various real-world design examples that highlight the theoretical foundations and practical design decisions, development issues and validation methodologies. With the increasing availability, quality, and affordability of virtual/augmented reality and immersive gaming hard- and software, there is an increasing need for improved navigation interfaces that combine high usability and learnability with a more embodied interaction that goes beyond gamepads and mouse/keyboard approaches. This topic is highly relevant, as many domains benefit from well-performing navigation techniques, from games to big data exploration scenarios. Furthermore, due to the recent (re)advent of virtual reality, this area has become even more relevant as many users are affected by the performance of navigation interfaces and techniques. Thereby, anything from hand-operated to full-body controlled interfaces will receive detailed attention.

## Intended Audience

The intended audience encompasses researchers, students, developers and practitioners who can benefit from an up to date, practical and well-founded overview and practical discussion to design new or improve upon existing navigation techniques for a wide range of domains.

## Prerequisites

There are no direct prerequisites for the course, though some experience with Virtual Reality or immersive gaming will be useful.

## Content

***Theory: Foundations of spatial navigation, techniques and devices***

This session will provide the theoretical foundation on top of which the subsequent practical design application session will be built. An introduction will guide the attendees through the general structure and concepts of the course. Furthermore, we provide an introduction to psychophysical aspects underlying navigation, and an overview and categorization of various navigation techniques, paradigms, and devices reflecting the introduced psychophysics. In detail, this section encompasses the following:

**Introduction**. An overview of the course, and its' motivation, goals and structure. Furthermore, specific challenges of design, development and validation of techniques and devices will be provided, as well as an overview of relevant domains where navigation interfaces are deployed.

**Principles of navigation**. The psychophysics of navigation, including wayfinding and self-motion perception, as well as adverse side effects and guidelines

**Navigation paradigms and devices**. An overview of navigation paradigms and devices.

***Practice: Designing (affordable) interfaces***
Building on the foundation of the previous session, this session we will take a closer look at different methodologies to design, develop and validate (novel) navigation techniques and devices. We will conclude with a series of practical, real world examples, in both lecture and practical demonstration format. Thereby, we will focus in particular on low-cost solutions that can be readily implemented using limited resources, either by using and repurposing readily available existing devices, or by (rapid) prototyping of novel interfaces. As such, participants will gain a deeper understanding of different navigation approaches and underlying psychophysical aspects, and skills necessary to design, build, and validate novel navigation interfaces.

**Design, development and validation of navigation techniques and devices**. Design and development approaches, including design principles and iterative design techniques. Furthermore, relevant validation approaches will be provided.

**Case studies**. A series of case studies, in part using the principle of repurposing - the usage of existing devices for new purposes - and rapid prototyping of novel interfaces. Live demonstrations are included.

**Q&A session.** A final Q&A session, with a brief summary and discussion

## Practical work

The second lecture block is completely dedicated to practical aspects of navigation interface design and validation. Along various examples, we will discuss the design steps of various navigation interfaces, and look into key validation steps. This part of the lecture is driven by the involvement of the participants, through an "open discussion" format, and involves explanations along code samples.

## Instructor background

**Ernst Kruijff** is interim professor for computer graphics and interactive environments at the Institute of Visual Computing, Bonn-Rhein-Sieg University of applied sciences, where he heads the 3DMi group. The group focuses on the human factors driven design of multi-sensory 3D user interfaces. Previously, Ernst among others worked at CURE, Graz University of Technology, Fraunhofer IMK, and Bauhaus University where he coordinated several large German and European research projects in the field of virtual and augmented reality. He received his PhD (with honours) from Graz University of Technology, and an M.A. from Utrecht University, Netherlands. His work has been presented at conferences such as IEEE VR, 3DUI and ISMAR, and ACM VRST. Ernst has also presented multiple courses at ACM SIGGRAPH (3D user interfaces 2000, unconventional interfaces 2004) and ACM CHI (2008, 2009, both on 3D user interfaces), as well as other conferences (IEEE VR 1999, ACM VRST 2000, both on 3D user interfaces, and IEEE VR 2017 on Navigation interfaces). Also, he has been teaching classes since end of the nineties on virtual reality, digital design methods, 3D user interfaces, interactive systems, games technology and computer graphics to university students. Finally, Ernst is co-author of the standard reference in the field of 3D User Interfaces (LaViola et al. 3D User Interfaces – Theory and Practice, 2nd Edition, Addison-Wesley, 2017).

**Bernhard E. Riecke** is associate professor at the School of Interactive Arts & Technology (SIAT) at Simon Fraser University (SFU) and associate member

of the SFU Cognitive Science Program. Bernhard heads the iSpace Lab which combines multidisciplinary research approaches and immersive virtual environments to investigate self-motion perception and what constitutes effective, robust, embodied and intuitive human spatial cognition, orientation and behaviour as well as presence and immersion. This fundamental knowledge is used to guide the design of novel, more effective human-computer interfaces and interaction paradigms that enable similarly effective processes in computer-mediated environments such as virtual reality, immersive gaming, and tele-operation/tele-presence. Prior to joining SFU, Riecke worked for a decade at the Cyberneum, an interdisciplinary virtual reality research lab at the Max Planck Institute for Biological Cybernetics, DE, as well as Vanderbilt and UC Santa Barbara. His work spans theoretical and applied domains and is published in journals including Frontiers, Journal of Vision, ACMTAP, Experimental Brain Research and Presence, and conferences including IEEE VR, ACM-CHI, ACM SIGGRAPH, ACM-SUI, ISEA, and Spatial Cognition. Bernhard teaches classes on immersive environments/Virtual Reality, game design, human-computer interaction and cognition, and research methods and recently gave a TEDx talk on the potential of Virtual Reality.

## Resources

A dedicated web site has been set up to promote the course, as well as make available auxiliary material and useful resources. It can be accessed at: http://ispace.iat.sfu.ca/project/vr-navi-tutorial/