Vorbesprechung Praktika & Projekte

Prof. Dr. Hannes Kaufmann
Prof Dr. Horst Eidenberger
Prof. Dr. Walter Kropatsch
Dipl.-Ing. Soroosh Mortezapoor
Dr. Hugo Brument
Dr.tech. Jiri Hladuvka

E193-03 Virtual & Augmented Reality Research Group
Institute of Visual Computing & Human-Centered Technology
TU Wien, Austria
Courses

- Winter Semester 2022
  - Praktikum aus Visual Computing 1, 6 ECTS
  - Projekt aus Media and Human Centered Computing 1, 6 ECTS
  - Project in Computer Science 1, 6.0 ECTS

- Summer Semester 2023
  - Praktikum aus Visual Computing 2, 6 ECTS
  - Projekt aus Media and Human Centered Computing 2, 6 ECTS
  - Project in Computer Science 2, 6.0 ECTS

- Both semesters
  - Bachelorarbeit für Informatik und Wirtschaftsinformatik; 10 ECTS
  - Master Thesis, 30ECTS
**Project Courses: General Info**

- **Supervision**: regular meetings with supervisor (e.g., bi-weekly)

- **Hardware**: Suitable lab equipment is provided

- **Process**: literature research, iterative design and development of solution, evaluation and presentation

- **Strong practical component**: independently implement a prototype (hardware and/or software)

- Option to work in a small group (2 people)

- All topics available at
  - [https://www.cg.tuwien.ac.at/courses/Topics](https://www.cg.tuwien.ac.at/courses/Topics)
  - [http://www.vreeclimber.at/student_projects/](http://www.vreeclimber.at/student_projects/)
  - TISS course pages
VIRTUAL & AUGMENTED REALITY

Univ.Prof. Mag. Dr. Hannes Kaufmann

Research Staff

Postdocs: Peter Kán, Iana Podkosova, Christian Schönauer, Francesco De Pace, Hugo Brument
PhDs: Khrystyna Vasylevska, Emanuel Vonach, Soroosh Mortezapoor, Mohammad Mirzaei
   + 3 external PhDs

Students: 15 graduate and undergraduate students involved in research
Virtual & Augmented Reality Themenbereiche

- High Quality Rendering in AR
- Real Time Ray Tracing in VR
- Firefighter Training with Virtualizer
- Haptic Feedback
- Object Detection and Segmentation in Live 3D Reconstruction
- Redundant Walking
- Automated 3D Model Generation
- Live 3D Reconstruction for First Responders
- Shared Collaborative Virtual Spaces Navigation
- Wide Area Multi-User Optical Localization
- Total: 138.9 FPS

- Input
- Rendering & Viewing
- Localization (Tracking)
- Interaction
- Distribution
- Collaboration
- Authoring
- Perception

- Output

- Unity
- Unreal Engine
Next Steps...

Send us an email with the following information:
• Which course you require credits for
• The idea/topic you wish to pursue
• Your name and Matrikelnummer

To: <topic supervisor>
CC: hannes.kaufmann@tuwien.ac.at

We will make individual agreements about
• supervision
• hardware pickup
• specific tasks
List of topics
AUGMENTED REALITY
**Outdoor Augmented Reality (AR) Tracking System**

- AR tracking solutions are not usually suitable for large outdoor areas

- **Task**: development of an outdoor GPS-based tracking system for wearable AR devices (e.g., Magic Leap, Microsoft HoloLens)
  - Verify accuracy of a GPS system (REDCatch):
    - Comparison with the wearable AR device tracking system
  - How to use GPS positional data to improve tracking
  - User tests to assess the effectiveness of proposed solution from a human-centered perspective

- **Setup/IDE**:
  - Many possible solutions (to be discussed)
    - Windows (Unity3D)
    - Android (for GPS)
    - C#, Java/Android

- **Scope**: Master

- **Supervisor**: francesco.pace@tuwien.ac.at
AVATARS AND MULTIUSERS APPLICATIONS
Co-Embodiment: Non-Human Avatar

- Suitable for: Bachelor thesis, PR

- Goal: develop methods for two (or more!) users to embody and control a non-human avatar together
  - In contrast to the previous topic, different users can control completely different parts of the avatar
  - The avatar should be too complex for single-user control

- Tasks
  - Design or find a non-human avatar (any ideas on the body schema welcome!)
  - Implement mapping shared motion control
  - Develop experimental tasks to demonstrate and test co-embodiment

- Environment, hardware etc.: Unity3D, Oculus Quest or HTC Vive, potentially hand tracking and inverse kinematics

- Contact: Iana Podkosova yana.podkosova@tuwien.ac.at, Hugo Brument hugo.brument@tuwien.ac.at
Mixed-Agency interactions in VR

- Context: A VR environment where multiple avatar-embodied users and multiple virtual agents (that look like users but are controlled by computer algorithms) perform tasks together
- Examples: Team sports in VR where some players are human and some are agents, large simulations of building evacuation, social VR platforms with human users and virtual agents
- Goal: Study how users will interact with each other and with virtual agents
- First step: experiment with 2 users and one agent

- Contact: Iana Podkosova yana.podkosova@tuwien.ac.at
Multi-user VR Game with virtual agents

• Two users and one agent, the goal is to collect colored cubes, insert them into slots in walls, give them to other users
• Goal: study how users perform collision avoidance with each other and with agents; study how users would choose interaction partners
• Task: Integrate agent animations into the multi-player game scenario, improve user avatars, implement the recording of experimental metrics
  – Game algorithm itself is implemented
• Tools and hardware: Unity 3D, PUN 2 networking plugin, Oculus Quest
• Requirements
  – English
  – Unity3D
  – VR experience and multi-player experience is an advantage
• Suitable for: Project, possible to follow up with MA thesis about mixed-agency interactions
• Contact: Iana Podkosova yana.podkosova@tuwien.ac.at
ARTIFICIAL INTELLIGENCE IN VR
“Intelligent” Virtual Human in VR

• Create realistic virtual agent in VR environment using Unity 3D or Unreal Engine
• Connect the virtual character with NVIDIA Riva and Rasa systems
  – speech synthesis
  – natural language processing
  – intelligent conversations
• Animations and lip sync
• Connect game engine with grasshopper in Rhino
• Control parametric script with speech

Contact: peter.kan@tuwien.ac.at
Scope: PR, Master thesis
ROBOTICS AND VR
Mobile Autonomous Navigation: Stair Detection

- We provide a mobile robot (Spot, from Boston Dynamic) capable of autonomously exploring unknown environments (ROS-based solution)

- **Task**: Enable Spot to explore multi-floor environments, connected by stairs
  - Implement a solution for stair detection:
    - RGB and/or RGB-D cameras
  - Implement a solution for “Stair awareness”
    - The robot should know whether it is walking on a stair or not

- **Setup/IDE**: Ubuntu, ROS (Robot Operating System)
- **Scope**: PR

- **Supervisor**: francesco.pace@tuwien.ac.at
CoboDeck

A Large-Scale Haptic VR Interactive System Using a Collaborative Mobile Robot
Safe Haptic Feedback

• **Setup:**
  • Safe RB-Kairos mobile platform with arm & HTC Vive Pro
  • Windows + Unity, Ubuntu + ROS

• **Various Tasks available:**
  • ROS (Linux):
    • Implementation & integration of safety guidelines
    • Development & implementation of a prop change procedure for the robotic arm
  • Fast haptic feedback based on vision and/or prediction
  • Shape simulation with a square flat prop
  • Individual adaptation to user’s behavior

• **Scope:** VR: AT, PR, SE, thesis

• **Supervisors:** emanuel.vonach@tuwien.ac.at, khrystyna.vasylevska@tuwien.ac.at
Vision for Robot: Detect the VR User

- **Task:** Enable fast user detection on the robot for safety and interaction
  - Implement a solution for user detection:
    - Whole body or only hands/legs
    - Tell apart user from a static obstacle
    - Test for optimal recovery (collision avoidance) behavior
    - For thesis:
      - Explore options for time-optimization
      - Prepare and help running a user study

- **Setup/IDE:** Ubuntu, ROS (Robot Operating System)
  **Prerequisites:** Basic Linux command, Python 2.7 & C++
  **Scope:** PR, Master thesis

- **Supervisors:** khrystyna.vasylevska@tuwien.ac.at, soroosh.mortezaipoor@tuwien.ac.at
Material Simulation With A Robotic Arm

• Sensations of texture, temperature, weight, rigidness, elasticity, etc. of an object is essential in providing VR users with realistic haptic feedback in VR.

• Task: Implementing a simulator of one of the properties that can be adapted for a robot using a simple lego-like hardware manipulation.

• Setup/IDE: C++ and/or Python, either ROS (Robot Operating System) or Unity

• Prerequisites: Programming with Python and/or C++, understanding of spatial transformations

• Supervisors: khrystyna.vasylevska@tuwien.ac.at
Safe Planning & Control of a Robot Arm for VR Use

• Moving a robotic arm close to an unaware immersed VR user can be dangerous.

• A robotic arm can alter the order of moving its different joints (finding and selecting different solutions for an inverse kinematic problem) to create a safer path for its joints to reach a certain goal by making changes in the arm path planning algorithm.

• **Task:** Employ and configure arm path planning algorithms and inverse kinematic solvers.
  • **Setup/IDE:** Ubuntu, ROS, Gazebo

• **Prerequisites:** Basic Linux commands, basic understanding of spatial transformations, maybe basic python.

• **Scope:** PR, thesis
Optimize Path Planning For A Mobile Robot

• **Objective:** Test different combinations of path planning algorithms for optimal movement of a mobile robot, which is hovering around an immersed user in a walkable VR brings new **challenges** including
  - Keeping safe distance to the user(s)
  - Stay as reachable as possible for providing services
  - Minimize collision probability

• **Task:**
  - Configure current implemented algorithms and evaluate results
  - Or implement new application-specific path planning algorithms

• **Setup/IDE:** Ubuntu, ROS (Robot Operating System)

• **Prerequisites:** Basic Linux commands, Python 2.7 or C++

• **Scope:** PR, thesis

• **Supervisor:** soroosh.mortezapoor@tuwien.ac.at
Analysis Of Human Behavior In Large VR Spaces

• We often need to know in advance what to expect from a VR user
• Task: Create a tool for data collection, analysis & prediction
  • Implement 1+ predictor for user’s actions:
    • Movement: walking / running / stopping
    • Touching objects
• Possible data sources:
  • Standard VR setup (HMD + controllers)
  • Full-body mocap
  • Brain-computer interface or bio signals
  • Various cameras
• Setup/IDE: C++, C#, or Python, Unity or ROS
• Prerequisites: Programming skills, understanding of predictive systems
• Scope: PR, Master thesis

• Supervisor: khrystyna.vasylevska@tuwien.ac.at
Robot Detection by Unaware VR User

• PR, Master thesis

• **Task:** Explore the conditions under which the user in VR might notice that there is a heavy platform is moving in the space near him/her
  • Together with supervisor implement a scenario of interaction with a moving robotic platform with arm in VR
  • (for thesis) Prepare and help running a user study
    This topic targets a scientific publication as a result.

• **Setup/IDE:** Unity on Windows, Ubuntu, ROS (Robot Operating System)

• **Prerequisites:** C#, Basic Linux command, Python 2.7 or C++

• **Supervisor:** khrystyna.vasylevska@tuwien.ac.at
Interested in CoboDeck?

**Supervisor:** Depending on topic
- Khrystyna Vasylevska
- Emanuel Vonach
- Soroosh Mortezaipoor

Send email for more information and discuss topics:

cobodeck@list.tuwien.ac.at
Safe Planning & Control of a Robot Arm for VR Use

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• Task: Employ and configure arm path planning algorithms and inverse kinematic solvers.
• Setup/IDE: Ubuntu, ROS, Gazebo
• Prerequisites: Basic Linux commands, basic understanding of spatial transformations, maybe basic python.
• Scope: PR, thesis

• Supervisor: soroosh.mortezapoor@tuwien.ac.at
HARDWARE INTERFACES FOR VR INTERACTION
Synthetic Heat in XR

• Thermal Grill Illusion
  – Alternating hot/cold areas produce burning heat sensation

• Task
  – Basic Task:
    • Build a (mobile) device that produces the thermal grill illusion
    • Should be small enough to be tested on various body positions (mainly hand/arm/face/neck)
  – Extended Task:
    • Heat controllable from XR application using e.g. Arduino
    • Wearable form factor
    • Use compressed air and electronically controlled pneumatic valves for cooling
    • Wireless control from mobile XR device etc.

• Topic for: PR, BA, (possibly DA)

• Contact: christian.schoenauer@tuwien.ac.at
Hanger Reflex

• A force illusion that accompanies involuntary body rotation

• Task
  – Development of an interface that generates the Hanger Reflex on different body segments (head, waist, legs).
  – Development of a proof of concept in Unity3D to show how users could be redirected in VR experimental platform using Unity3D

• Knowledge of Arduino/ROS/Microcontrollers

• Contact: hugo.brument@tuwien.ac.at
BUILDING INFORMATION MODELLING (BIM)
BIMCheck: Automatic comparisons of BIM models and real buildings

- Goal – compare how a building corresponds to its BIM model (3D model + metadata about a building)
- Find differences: missing/misplaced walls, deviations in dimensions, etc.
- Workflow: scan the building (room), match the scan to the BIM file, extract geometry from the scan, find differences between scan and BIM geometry
- Technology: LiDAR scanner (Ouster OS0-128), Kinect for Azure, Kudan SLAM tracking, Point Cloud Library (PCL), OpenCV etc.
- Contact: Iana Podkosova
  yana.podkosova@tuwien.ac.at
BIMCheck: Kinect Fusion with multiple Azure Kinects

• Task: integrate 3 Kinect for Azure devices into Kinect Fusion (large scale) algorithm, test various scenes and algorithm parameters

• Hardware and tools: Kinect for Azure (x3), Kinect for Azure SDK, C++, OpenCV, PCL (Point Cloud Library)

• Requirements
  – English
  – C++
  – Computer vision methods/OpenCV is an advantage

• Suitable for: Project (PR), can be extended to BA or MA thesis

• Contact: Iana Podkosova yana.podkosova@tuwien.ac.at
BIMCheck: Kudan SLAM accuracy evaluation

• Task: evaluate the accuracy of Kudan SLAM (commercial SLAM tracking solution) using Lighthouse tracking stations and HTC Vive trackers as ground truth

• Hardware and tools: Ouster LiDAR, HTC Vive trackers, existing platform that runs SLAM on Ouster LiDAR data

• Requirements
  – English
  – C++
  – Understanding of statistics is an advantage

• Suitable for: Project

• Contact: Iana Podkosova yana.podkosova@tuwien.ac.at
BIMCheck: Extract geometric primitives from the point cloud

- Task: find planes (floor, walls) in a point cloud scan

- BIM model can be used to find primitives (after the point cloud is registered in BIM – already implemented)

- Tools: C++, PCL (Point Cloud Library), existing platform for LiDAR point cloud to BIM registration

- Requirements:
  - English
  - C++

- Suitable for: Project, can be extended to MA thesis

- Contact: Iana Podkosova yana.podkosova@tuwien.ac.at
BIMCheck: Soll-Ist Abgleich/ target-scan comparison

• Task: compare the LiDAR scan of a room to the BIM model, find differences in positions and dimensions of elements

• The scan can be in the point cloud form or made of planes

• Tools: C++, PCL (Point Cloud Library), existing platform for LiDAR point cloud to BIM registration

• Requirements
  – English
  – C++

• Suitable for: MA thesis (can be combined with primitives extraction)

• Contact: Iana Podkosova yana.podkosova@tuwien.ac.at
BIMCheck: Kinect + LiDAR data integration

- Task: integrate Kinect depth data + Kinect Fusion data representation (TSDF) with LiDAR data, develop new data structures for scene reconstruction

- Tools: C++, OpenCV, PCL, existing platform for LiDAR data integration

- Requirements
  - English
  - C++

- Suitable for: Project, can be extended to MA thesis and combined with different topics (integration of 3 Kinect devices)

- Contact: Iana Podkosova yana.podkosova@tuwien.ac.at
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