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

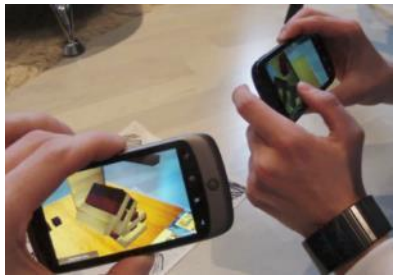
TU Wien, Austria

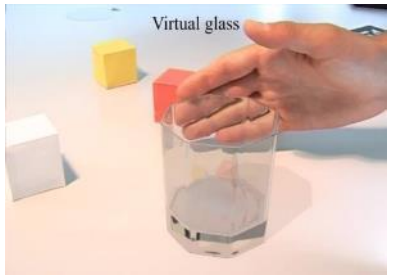
Courses

- 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
  - http://www.vreeclimber.at/student_projects/
  - TISS course pages



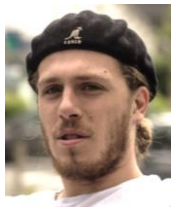


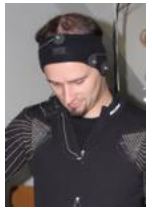
VIRTUAL & AUGMENTED REALITY

Univ.Prof. Mag. Dr.
Hannes Kaufmann

Center for Geometry and Computational Design

Research Staff





Postdocs: Peter Kán, Iana Podkosova, Christian Schönauer, Francesco De Pace, Hugo Brument

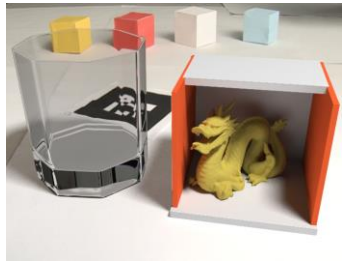
PhDs: Khrystyna Vasylevska, Emanuel Vonach, Soroosh Mortezapoor, Mohammad Mirzaei
+ 3 external PhDs

Students: 15 graduate and undergraduate students involved in research

Virtual & Augmented Reality Themenbereiche

Total: 138,9 FPS

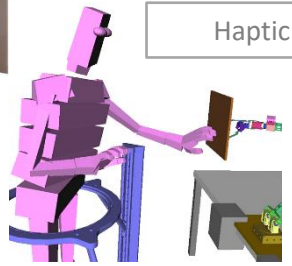
Real Time Ray Tracing in VR



High Quality Rendering in AR

Firefighter Training with Virtualizer

Haptic Feedback



Input

Rendering & Viewing

Localization (Tracking)

Interaction

Distribution

Collaboration

Authoring

Perception

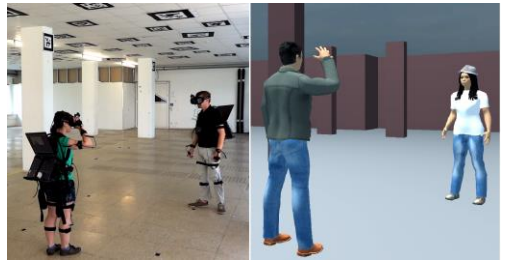
Output

Wide Area Multi-User Optical Localization

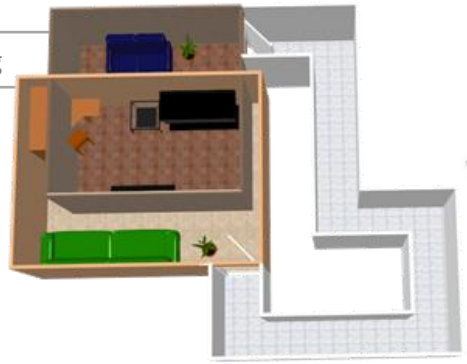
ioTracker

Shared Collaborative Virtual Spaces Navigation

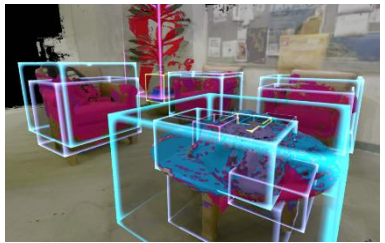
Live 3D Reconstruction for First Responders



Redirected Walking



Object Detection and Segmentation in Live 3D Reconstruction



Automated 3D Model Generation

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

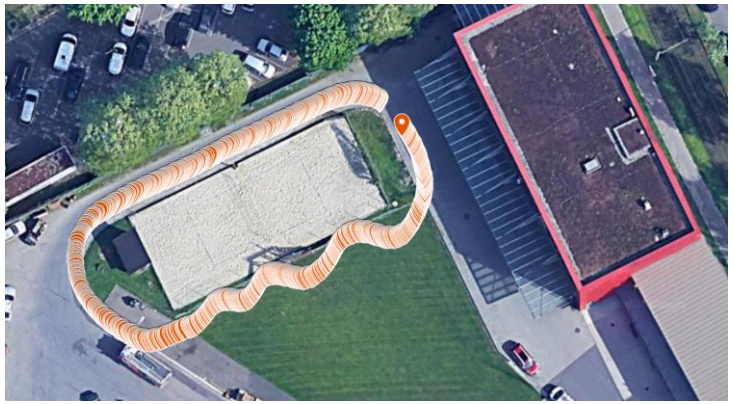
AUGMENTED REALITY

Virtual and Augmented Reality Group

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

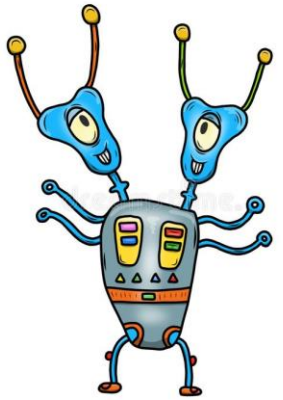


- **Setup/IDE:**
  - Many possible solutions (to be discussed)
    - Windows (Unity3D)
    - Android (for GPS)
    - C#, Java/Android
- **Scope**: Master

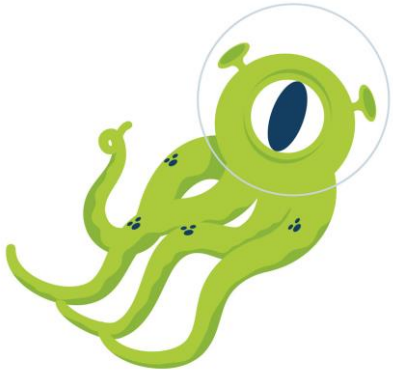
- **Supervisor:** francesco.pace@tuwien.ac.at

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

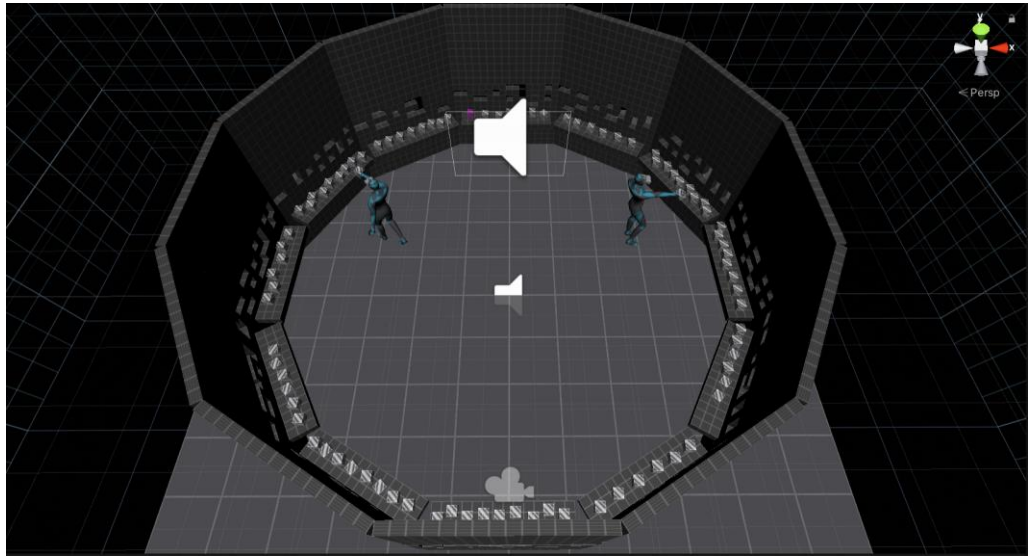
- Contact: Iana Podkosova yana.podkosova@tuwien.ac.at, Hugo Brument hugo.brument@tuwien.ac.at

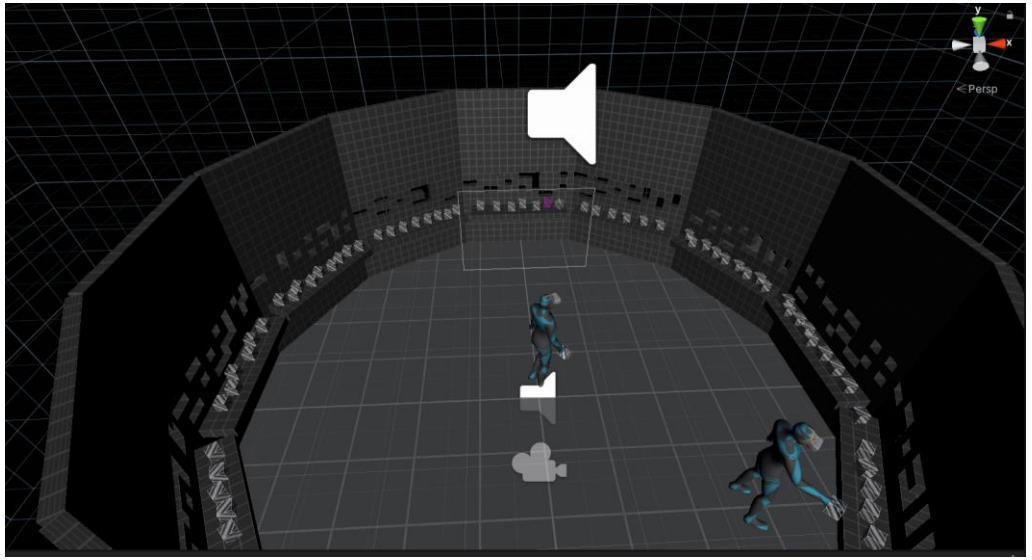
Virtual and Augmented Reality Group

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





Virtual and Augmented Reality Group

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

ARTIFICAL 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

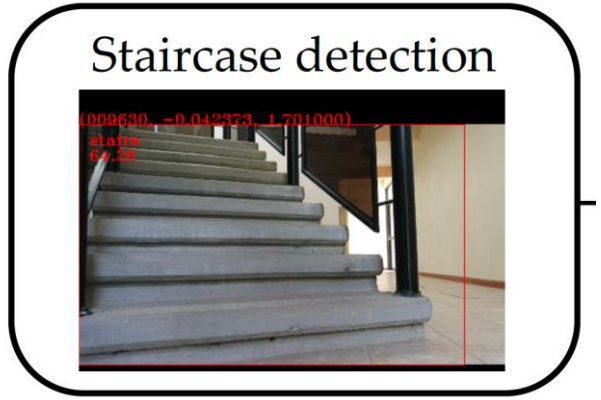
Contact: peter.kan@tuwien.ac.at
Scope: PR, Master thesis

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



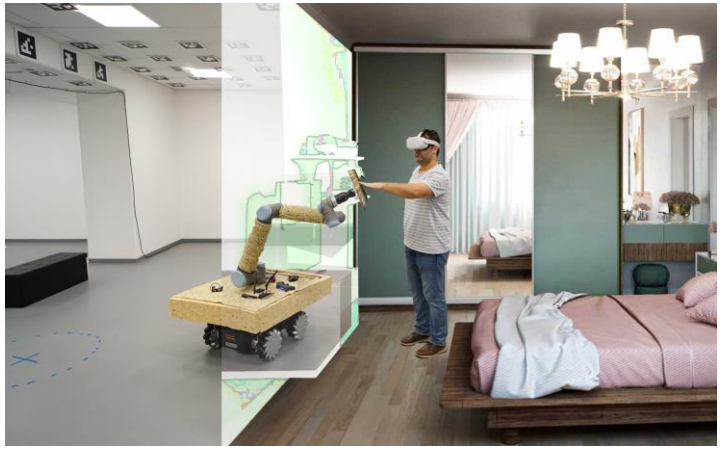
- **Setup/IDE:** Ubuntu, ROS (Robot Operating System)
- **Scope**: PR

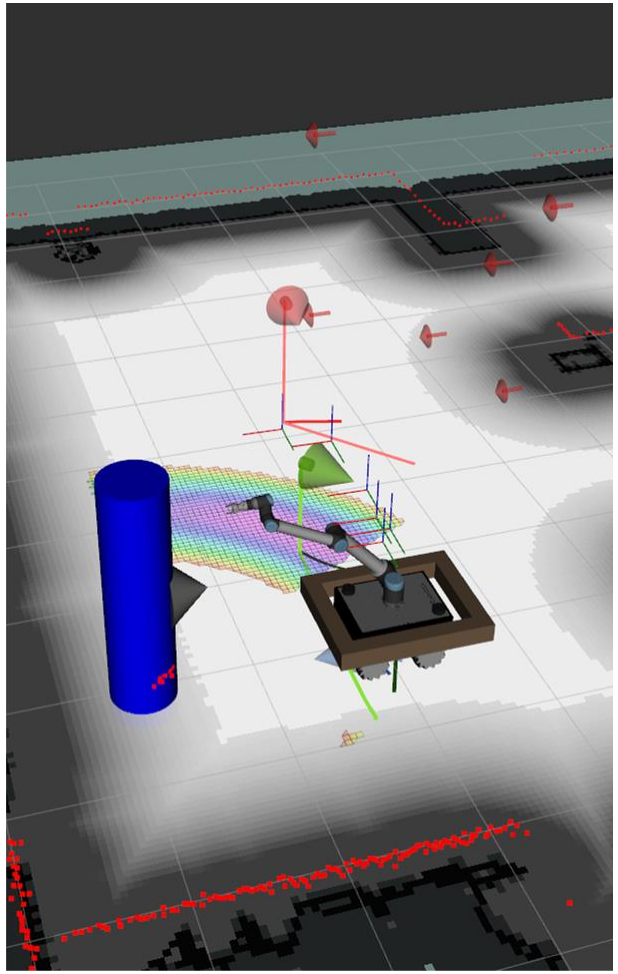
- **Supervisor:** francesco.pace@tuwien.ac.at

Virtual and Augmented Reality Group

CoboDeck

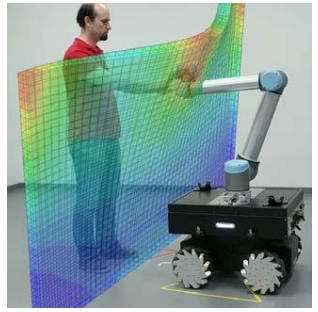
A Large-Scale Haptic VR Interactive System Using a Collaborative Mobile Robot





Safe Haptic Feedback

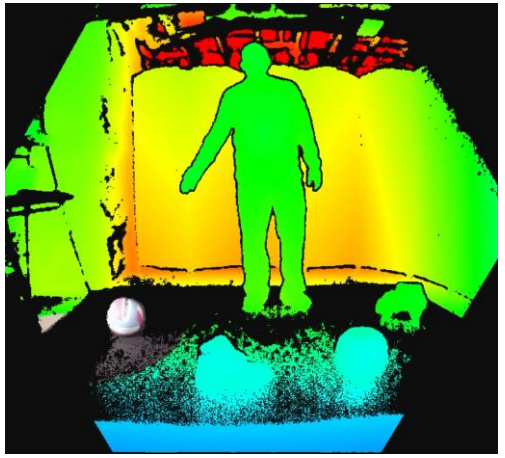
- ***Setup:***
  - Safe RB-Kairos mobile platform with arm & HTC Vive Pro
  - Windows + Unity, Ubuntu + ROS
- ***Various Tasks available:***
  - ROS (Linux):
    - Implementation & integration of safety guidelines
    - Development & implementation of a prop change procedure for the robotic arm
  - Fast 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,



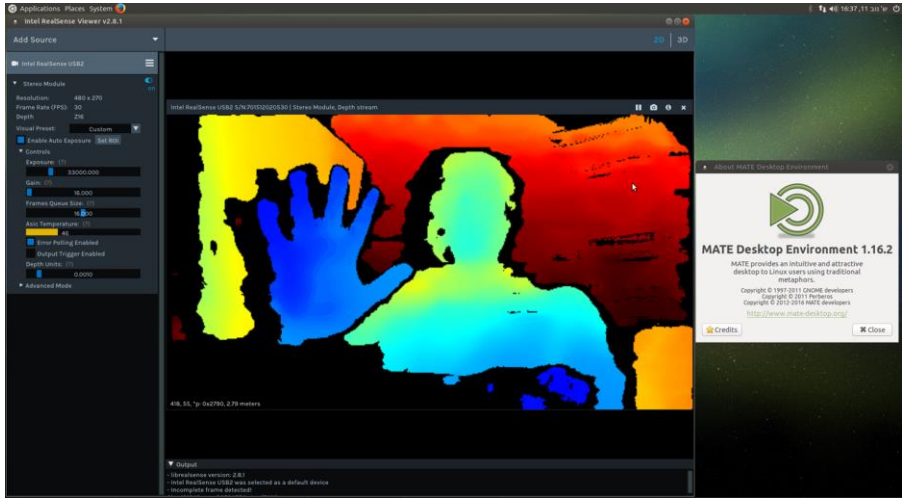
Virtual and Augmented Reality Group

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.mortezapoor@tuwien.ac.at

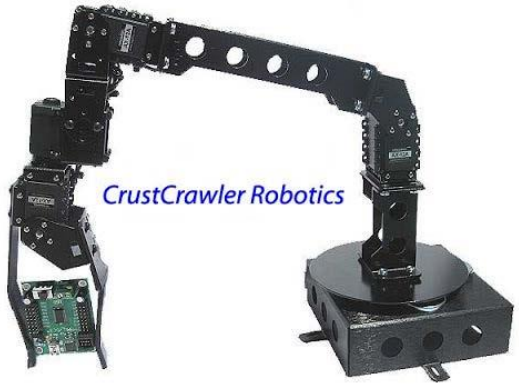


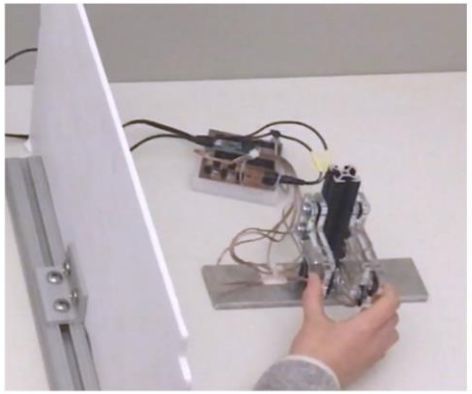
Material Simulation With A Robotic Arm

- 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





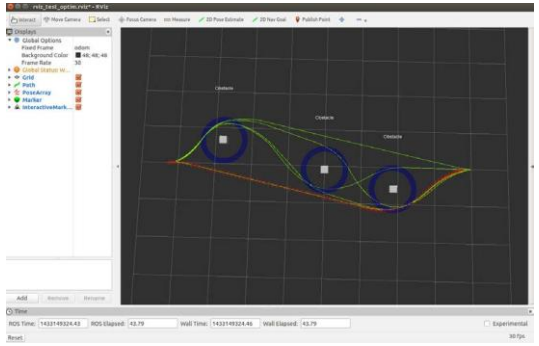
Safe Planning & Control of a Robot Arm for VR Use

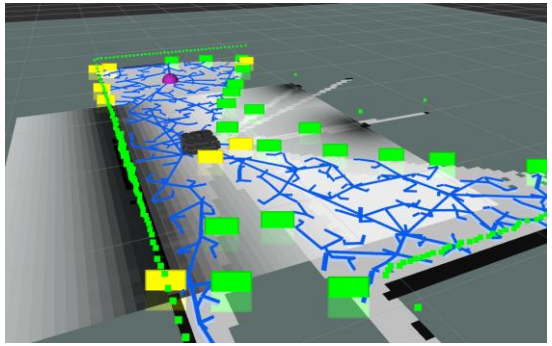
- Moving a robotic arm close to an unaware immersed VR user can be dangerous.
- A robotic arm can alter the order of moving its different joints (finding and selecting different solutions for an inverse kinematic problem) to create a safer path for its joints to reach a certain goal by making changes 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

Virtual and Augmented Reality Group

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





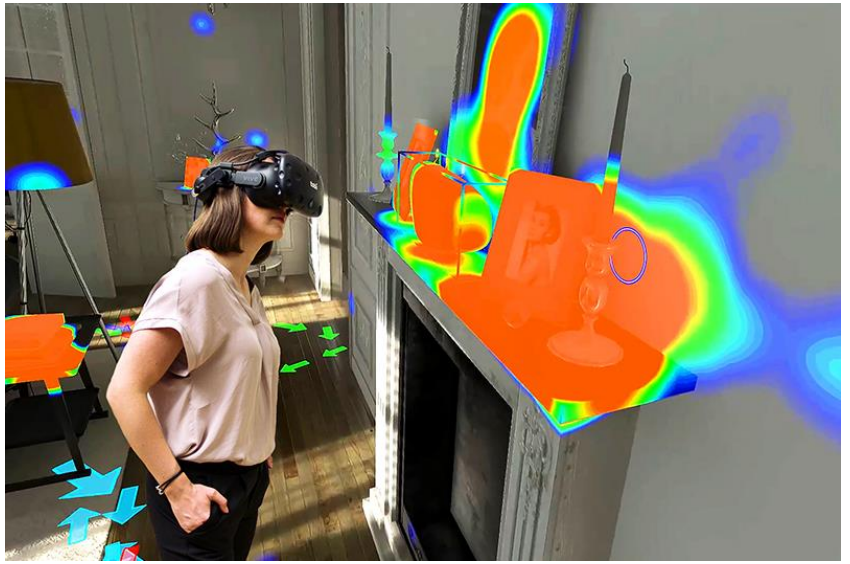
- **Supervisor:** soroosh.mortezapoor@tuwien.ac.at

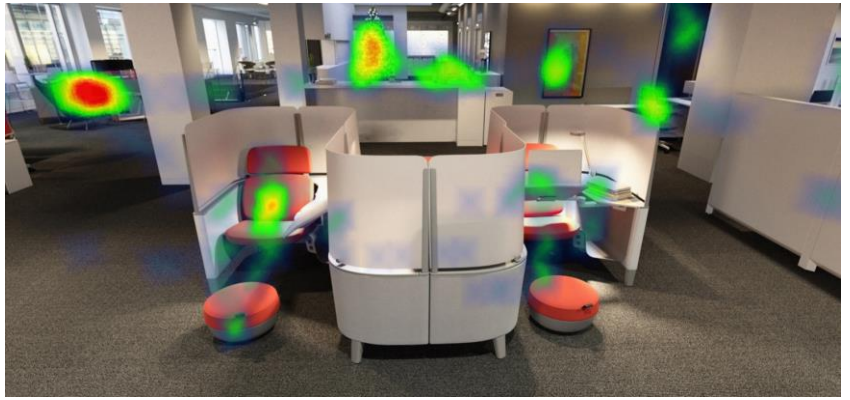
Virtual and Augmented Reality Group

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





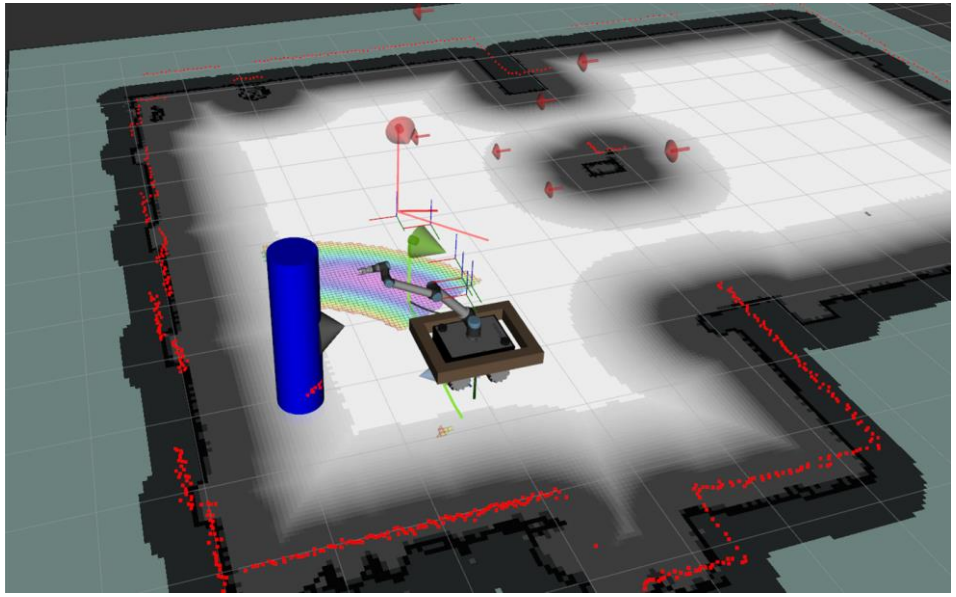
Robot Detection by Unaware VR User

- 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

Virtual and Augmented Reality Group

Interested in CoboDeck?



Supervisor: Depending on topic

- Khrystyna Vasylevska
- Emanuel Vonach
- Soroosh Mortezapoor

Send email for more information and discuss topics:

cobodeck@list.tuwien.ac.at

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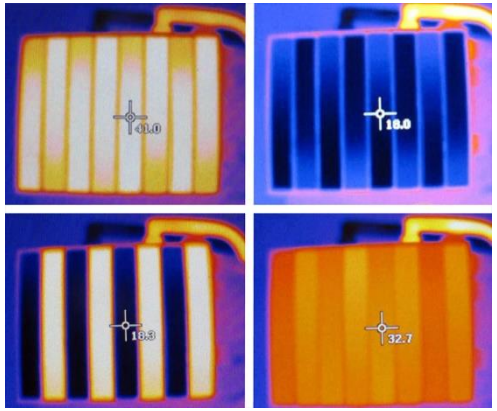
- **Prerequisites:** Basic Linux commands, basic understanding of spatial transformations, maybe basic python.
- **Scope:** PR, thesis

- **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 compresed 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

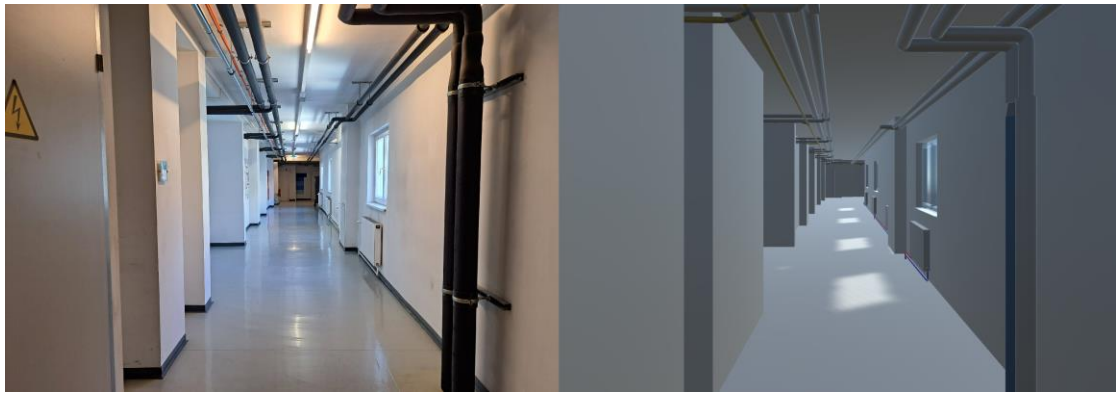
- Contact: hugo.brument@tuwien.ac.at

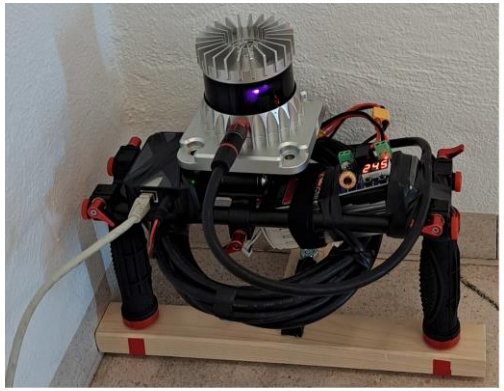
BUILDING INFORMATION MODELLING (BIM)

Virtual and Augmented Reality Group

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





Virtual and Augmented Reality Group

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

Virtual and Augmented Reality Group

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

Virtual and Augmented Reality Group

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

Virtual and Augmented Reality Group

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

Virtual and Augmented Reality Group

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

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

Questions?