

# Master's thesis topics in Networks and Distributed Systems (ND)

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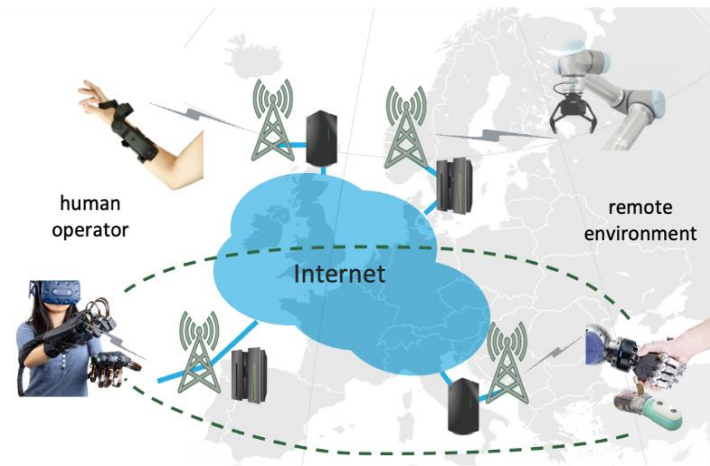
# **Topic 1: Immersive remote interactions leveraging Machine Learning**

# Motivation

- **Tactile Internet** is capable of delivering real-time control, touch, and sensing/actuation information through reliable, responsive, and intelligent connectivity
  - Applications: Remote work, remote education, remote care, etc.
- Not a lot of research implement the physical platform and specify the blockages in enabling a smooth quality of experience (QoE) during the interaction

# Use Case

- Focus on haptic and telepresence communications
- Remote interaction across the layers
  - Networking paradigms
  - Protocol support
  - Human perception
- Realize realistic remote interactions, low latency and reliable communication is the key
  - Network slicing (NS)
  - Multi-access edge computing (MEC) in 5G networks
- **Shortcoming:** Even providing the best possible latency and reliability may not be enough to ensure that interactive applications can satisfy users' requirements.
- **Solution:** Along with advances in networking paradigms, we need to provide cognitive latency hiding mechanisms based on the human perceptual tolerances.



# Sustainable Immersive Networking Laboratory (SINLAB)

VR headsets:  
Oculus Rift/Quest  
HTC Vive



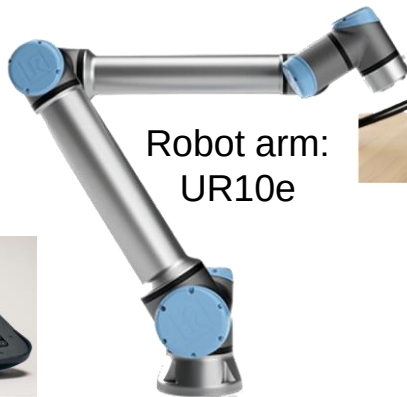
Ultrahaptics  
in-air tactile feedback



Vive  
Tracker



Bhaptics  
Tactsuit



Robot arm:  
UR10e

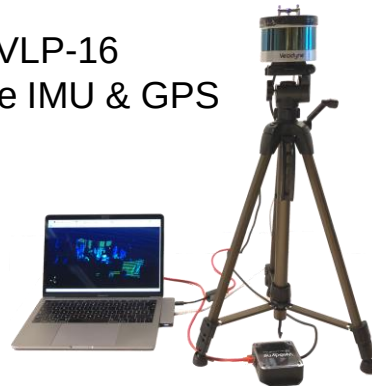


Project Northstar  
AR Headset



Shadow Dextrous Hand

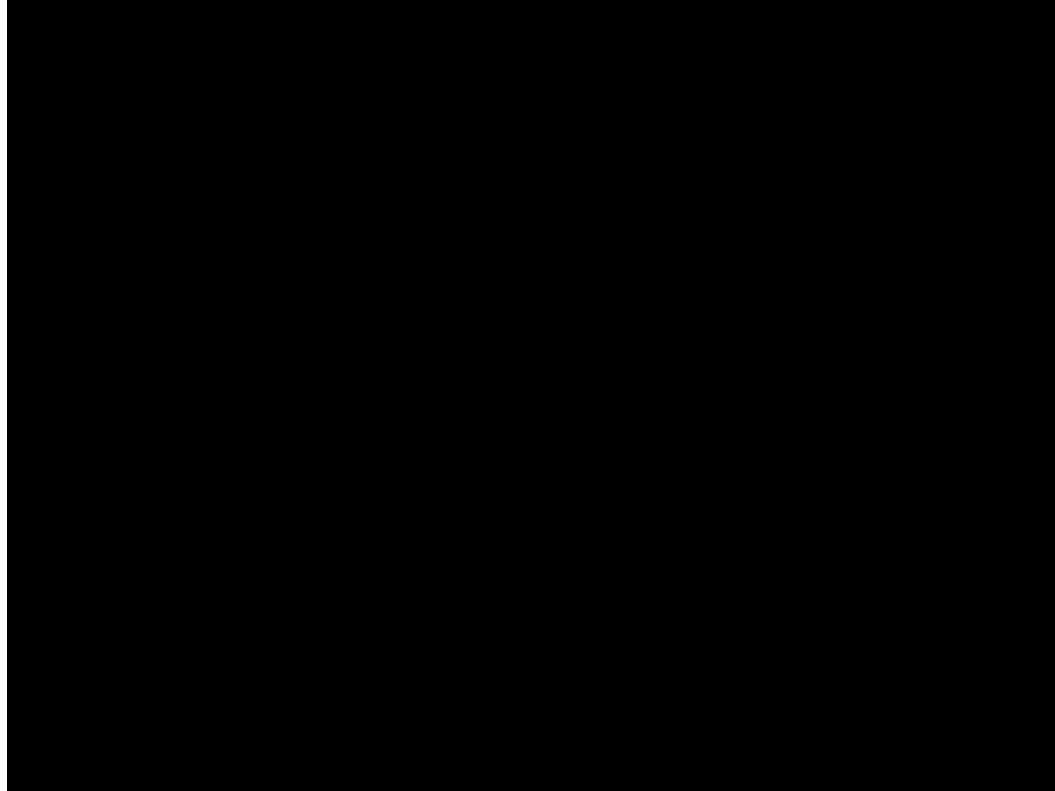
LIDAR:  
Velodyne VLP-16  
Tinkerforge IMU & GPS



Netronome Agilio  
CX 2x10GbE



# Shadow Hand



# Aspects to study

- Work in the intersection of networking, machine learning and robotics, and contribute to the multimodal remote interaction with multisensory feedback to create more immersive experiences.
- Exploration of personalized action prediction based on ML for hiding delays that can be expected from infrastructures that rely on 5G and beyond networks.
- Requirements:
  - Python, R, Matlab
  - Hands-on experience over interdisciplinary system design
  - ML/AI (data-based design)
  - Mathematical optimization (model-based design) in network protocol design



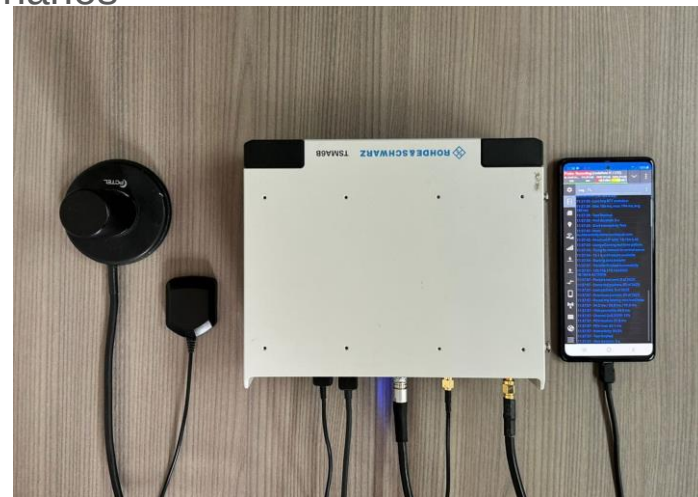
## **Topic 2: Empirical analysis of 5G network measurements using Machine Learning**

# Motivation

- The popularity of 5G networks is rapidly increasing
  - High bandwidth (eMBB), low latency (URLLC), and massive connectivity requirements (mMTC)
- 5G Non-Standalone (NSA) is being largely adopted for the rollout of 5G networks
  - No 5G Standalone (SA) deployments in Europe yet
- Empirical analyses on 5G operational networks are still limited
- It is key to investigate how 5G NSA affects network coverage and application performance

# Measurement Design and campaign

- Large-scale measurement campaign on 5G NSA commercial cellular networks for four major operators in Rome during a period of over 3 months.
- Commercial equipment from Rohde and Schwarz (R&S)
- Both passive and active measurements
  - Different locations, times of day, and mobility scenarios
- Dataset will become available as open-source



# Aspects to study

- Network coverage
  - Radio deployment strategies
  - End-user performance (e.g., throughput, latency)
  - User/device positioning
    - Development and testing of positioning techniques
  - 4G-5G co-existence in the same frequency spectrum
- 
- Requirements:
    - Python, R, Matlab
    - ML/AI (data-based design)



## **Topic 3: Immersive Musical Human-AI Interactions**

# Motivation: "Rock On with Your Virtual Drummer Buddy!"

## Problem Statement:

- Rocking out without a drummer? Drum sets: expensive, loud, and bulky.
- AI solution in the browser - Always ready, always in sync. E.g., Google's DrumBot.
- But where's the fun without seeing your drummer in action?



## The Fun & Challenge:

- Musicians thrive on visual cues: signaling beats, groove maintenance, and overall jamming joy.
- Our Goal: An engaging virtual "drummer buddy" that rocks out with you.

# Aspects to study: "Designing the Ultimate Drummer Buddy"

## Lab & Team:

- Join the Sustainable Immersive Networking Lab (SIN-LAB).
- Collaborate in a team setting; Benefit from a wide range of cutting-edge equipment.

## Learning Outcomes:

- Merge technical & creative talents.
- Dive deep into interdisciplinary system design, user studies, and XR-focused human-AI interactions.
- Potential to publish findings & attend top-tier international conferences.

## Skills Needed:

- Courses: IN5060.
- Programming: Python, C++ (Unreal) or C# (Unity).
- Passion for VR and, of course, music!

# Skills & Opportunities: "Jam with Us at SIN-LAB!"

## Design Problem: Avatar Creation

- What's your drummer's vibe? Human, octopus, Skeletor?
- How should it look, act, and react to ensure a fun jam session?

## Mapping Problem: Action Synchronization

- Syncing avatar movements with musical elements and webcam-captured user expressions.
- Ensuring the user feels a connection with their virtual drummer buddy.

## Research & Evaluation:

- Rock music jam session scenario.
- Design avatars & map actions to drum loops.
- Conduct user studies: How do design choices affect the Quality of Experience (QoE)?



## **Topic 4: Continuous body emotion recognition during creative tasks**

## Motivation: "Deciphering Emotions in Creativity"

- Diving into the nexus of technology and human emotion.
- Goal: Uncover human engagement nuances during creative tasks.
- Method: Non-invasive techniques. Think cameras, daily tools, no fuss!

# "Why Study Emotions in Creative Tasks?"

## 1. Emotion Recognition's Potential:

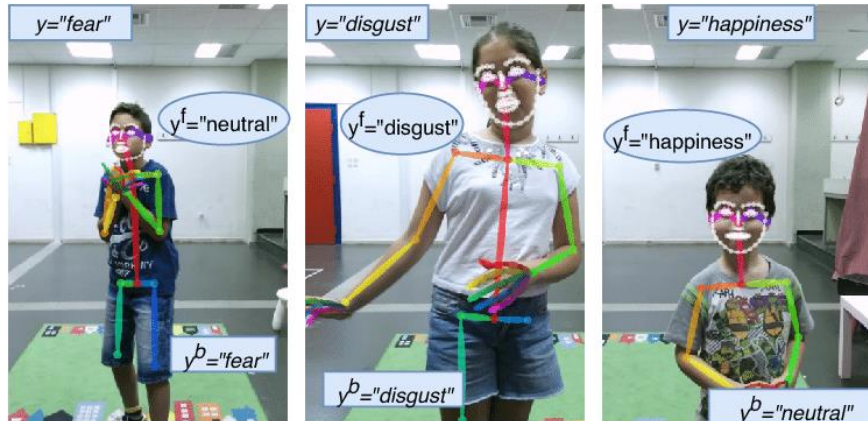
- Healthcare: Monitor well-being, mental health detection, enhance treatments.
- Entertainment: Real-time audience feedback for content refinement.
- Education: Boost learning through emotional engagement tracking.

## 2. Creative Task Benefits:

- Rich data: Broad spectrum of emotional complexities.
- Uncover human cognition insights: Tailoring tools and spaces for improved creativity.

# “What will you be working on?”

1. Emotion Recognition:
  - Use machine vision for emotion detection in creativity.
2. Deep Learning:
  - Advanced algorithms to interpret emotion-related physical cues.
3. Sensing technologies:
  - Evaluate regular equipment's efficacy in real-world emotion tracking.



## Suggested skills & courses

### 1. Courses:

- IN5060
- IN4260MCT

### 2. Skill Set:

- Foundation in machine learning & computer vision.
- Interest in human-computer interactions.
- Programming: Python & Web development.