

### Ambient Intelligence Project topics

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### Topic 01: Skill prediction from IMU data

Classify the skill in which persons are performing specific tasks.

- IMU data (Acceleration, Gyroscope)
- Three tasks
- Two skill levels labeled





(a) Finger-to-Nose Test

(b) Box and Blocks Test

(c) 9-Hole Peg Test





## **Topic 02: Skill prediction from first-person video**

classify the skill in which persons are performing specific tasks.

- 1st person video data (Hololens II)
- Three tasks
- Data to be collected by the group



(a) Finger-to-Nose Test

(b) Box and Blocks Test

(c) 9-Hole Peg Test





### **Topic 03: Blind orientation of mmWave data**

Rotate and combine point-cloud data appropriately.

- mmWave point cloud data (x-y-z-time)
- Identify relative rotation between point-cloud pairs
- Merge data and apply classification





### **Topic 04: Sound Event Localization and Detection**







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### **Topic 05: Separation of moving body parts**

- Separation of all moving parts related to the motion.
  - For instance, arms for doing the gesture, legs while walking.
  - Rope skipping requires the use of both hands and legs.
- Exclude other bodily activities not related to movement.
- Dataset: Video data from participants performing different gestures and motions.











# Topic 06: Feature space object recognition and separation

- Object-related information localization in feature space.
- Separate/add specified objects from/to an image in feature space, with less effect on features of other objects in the image.
- Dataset:
  - <u>CIFAR-10</u>: single object recognition
  - <u>PASCAL VOC</u>: multi-object recognition

input data





possible representation in feature space





### **Topic 07: Ballistocardiography**

#### Background

- Movement of the heart propagates through the body and can be measured at the body surface
- · Principle of ballistocardiography, measurement by precise acceleration sensors
- Since it is an acceleration signal, the signal processing is not trivial.

#### Topic

- Complex signals should not only be processed in the cloud
- Sensor-based data processing is a goal here, which requires lightweight
  processing of the data
- Embedded AI, e.g. using Tensorflow light, is a solution to perform complex data processing by pre-trained models on resource-limited hardware.

#### Task

- Creation of models for the detection of BCG signals, in particular the IJK complex.
- · Further analyses desirable, e.g. determination of heart rate variability
- Strong focus on lightweight models that can be run on resource-limited hardware
- Real hardware (e.g. microcontrollers or FPGAs) may also be used to demonstrate the methods









### Topic 08 & 09: RFID sensing

### **Target:**

The design and evaluation of a flexible UHF <u>RFID</u> **reader** using <u>USRP</u> (Universal Software Radio Peripheral) in conjunction with software that should be developed in the open-source **GNU Radio** framework

#### Topic 1:

Developing communication protocol between the <u>USRP-based</u> reader and a UHF RFID tag using Phase-shift keying (PSK) modulation

#### Topic 2:

Forcing several RFID tags to <u>backscatter</u> in carefully selected groups using the <u>USRP-based</u> reader





### **Topic 10: Speech recognition**

From an age-related speech dataset, train a mobile NN architecture (e.g., MobileNet) to differentiate between people of different ages from their speech features.

Consider speech features such as acoustic features (level modulation) and linguistic features (language-level patterns incl. rhythm). If also capturing the data manually bear in mind the possibility of the presence of speech disorders in young individuals in the participants selection. The model must be able to be deployed on-device without the need of the use of a server.





### **Topic 11: Eye tracking**

From an age-related eye tracking task dataset (e.g., reading a text on a screen at a close distance, or focusing on a moving target at close range), train a mobile NN architecture (e.g., MobileNet) to differentiate between people of different ages from their visual features.

Consider visual features abnormalities that cause impact on accuracy and performance of the tasks such as blurred vision, double vision, difficulty moving word to word, as well as latency while following a moving object or shifting gaze from one object to another. If also capturing the data manually bear in mind the possibility of the presence of vision disorders in young individuals in the participants selection. The model must be able to be deployed on-device without the need of the use of a server.





# **Questions?**

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### Literature

- C.M. Bishop: Pattern recognition and machine learning, Springer, 2007.
- R.O. Duda, P.E. Hart, D.G. Stork: Pattern Classification, Wiley, 2001.

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