Baden-
Württemberg
Stiftung
WIR STIFTEN ZUKUNFT

Forschungsergebnisse

Optische 3D-Sensorsysteme für mobile Anwendungen

der Baden-Württemberg Stiftung gGmbH

FORSCHUNGSTAG 2022

Context Aware Mobile 3D-Multi-Sensor System
- *Komo3D* -

Grischan Engel[1], Faraz Bhatti[1], Lanxiao Li[2],
Thomas Greiner[1], Michael Heizmann[2], Franz Quint[3],

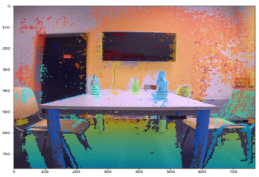
[1]Pforzheim University, [2]Karlsruhe Institute of Technology (KIT),
[3]Karlsruhe University of Applied Sciences

Abstract

The use of deep neural networks (DNN) for 3D-image processing significantly enhances visual cognition of mobile systems by considering spatial information. However, training and execution require high computing power. This is crucial in applications with real-time constraints and limited resources. Current approaches do not consider 3D-sensing and architectures solely focus on cloud- and/or edge-computing. In contrast, we propose a novel system architecture for the distributed and context aware usage of DNNs for image processing tasks in mobile 3D-multi-sensor systems. Moreover, different 3D-sensor principles are investigated to enhance scene and 2D-/3D-object detection. Finally, a case-study on a mobile 3D-multi-sensor system for wheeled walkers demonstrates benefits of the approach.

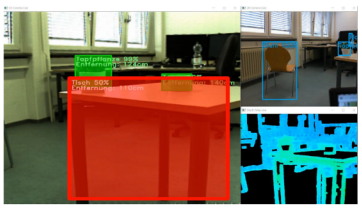
3D-Sensor Systems

3D-Sensor fusion
- Combining the advantages of plenoptic camera and Time-of-Flight (ToF) camera
- Fusion of point clouds captured from both sensors
- Result: Dense point clouds but movements captured by the ToF camera lead to noisy data (temporal averaging must be turned off)



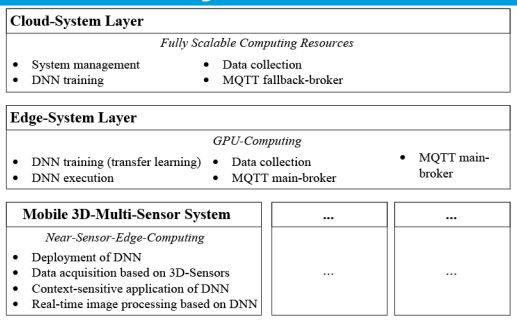
Alternative sensor: HemiStereo
- Semi-global matching for depth data
- Integrated Jetson Xavier for Embedded AI
- Accuracy of depth values not sufficient for object detection and classification
- 2D-object detection based on YOLO v4 and improved depth values in bounding boxes sufficient for obstacle warnings

Use Case: Assisted Wheeled Walker



- Mobile 3D-multi-sensor system for wheeled walkers
- Distributed execution of deep neural networks
- Assistance for elderly and/or handicapped people
- Warnings against obstacles and dangerous situations

Distributed System Architecture

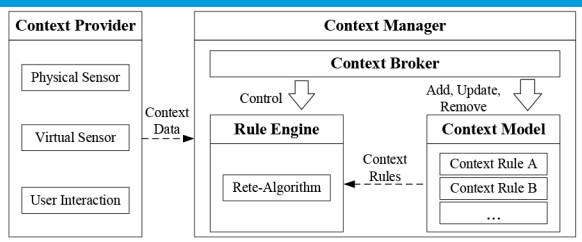


- Distributed computing power structure
- Cloud-, Edge- and Mobile-Systems (Near-Sensor-Edge)
- Cloud/Edge: Execution of DNN
- Mobile Systems: 3D-Data acquisition and display of warnings

2D-/3D-Object Detection

- **YOLO v4 for scene and 2D object detection (MobileNet v2 Backbone)**
  - Determines object bounding box, object class and scene class
  - Scene classification usable for context aware application of DNN
- **VoteNet-Lite for 3D object classification**
  - Object detection from point clouds
  - Determines orientation, position, size and object class
- Validated on CPU, ASIC and FPGA
- Optimized for mobile systems with limited resources

Context Aware Application of DNN



- Application of specialized DNNs depending on location
- Different location contexts: living room, kitchen, rest room, etc.
- Detection of location contexts: Scene classification (based on YOLO v4) and/or QR-codes
- Rule-based architecture to realize context sensitive behavior