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5G-Enabled AR Streaming System for Mobile Assistance in Technical Building Equipment (TBE) – System Overview and Preliminary Evaluation

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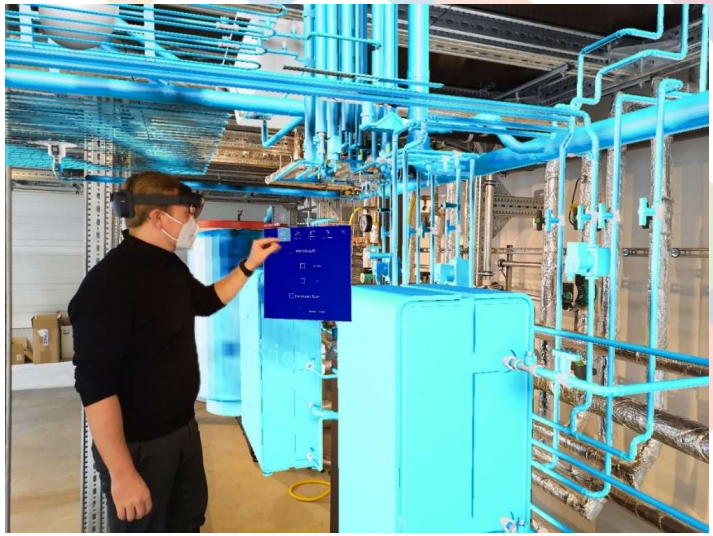
Motivation and Background

- **Challenges in Technical Building Equipment (TBE):**
  - Increasing complexity in **installation, maintenance, and inspection**
  - Conventional **GNSS-based localization fails indoors**
  - **Technicians need real-time navigation & component-specific data**
- **Solution:**
  - **5G + AR + Sensor Fusion**

  → Enables precise positioning & real-time overlays of digital content



Source: gia, E3D, Viega

Project Overview: National 5G Energy Hub (N5GEH) – Location Intelligence in Buildings with 5G for Augmented Reality (LocI4AR)

- **Objective:**
  - Development of a **5G-enabled mobile AR assistance system** for technicians
  - **Real-time positioning & BIM-based visualization in situ**
  - Integration of IoT-based real time sensor data
- **Key Technologies:**
  - **5G for real-time streaming & offloading**
  - **Indoor positioning (IMU, WLAN, BLE, 5G Fingerprinting)**
  - **Augmented Reality for component visualization & guidance**
- **Application Scenarios:**
  - **Facility maintenance, industrial inspections, energy systems**

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IMS Internet · Marketing · Services | IOX

WLH Wirtschaftsförderung im Landkreis Harburg GmbH

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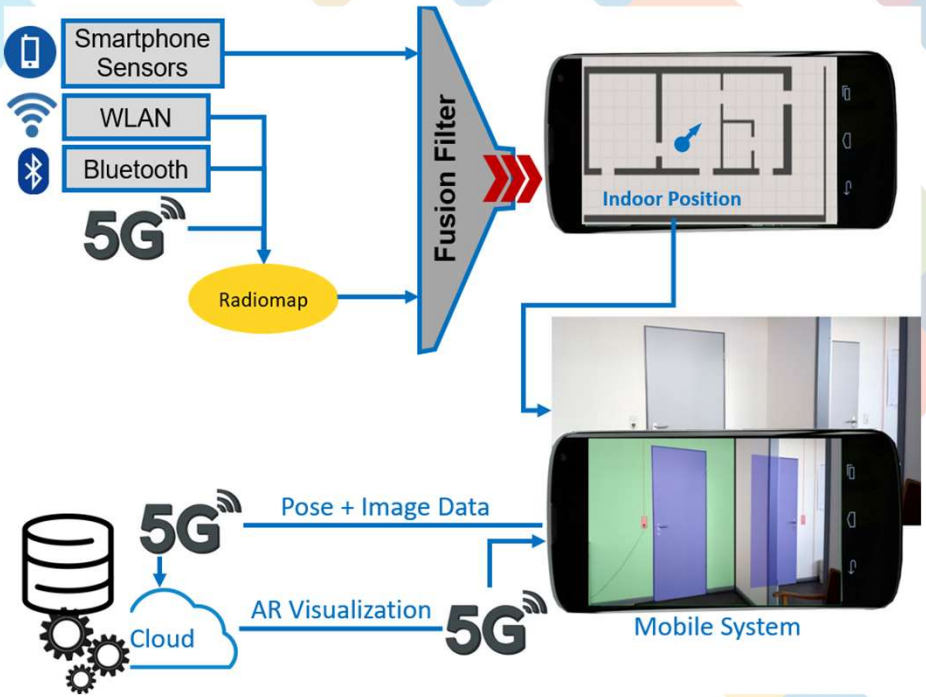
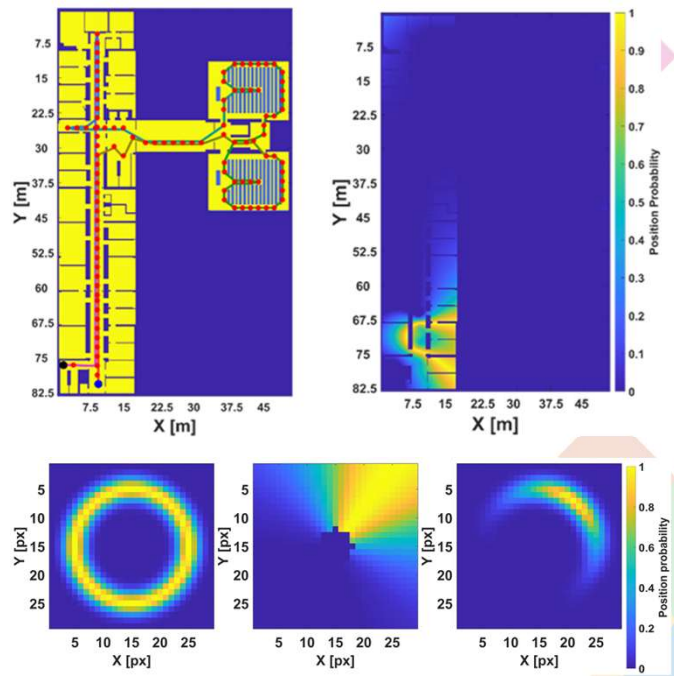
System Architecture – Core Components

- **Coarse Indoor Positioning**
  - Initial coarse location estimation **without GNSS**
  - Sensor fusion: **IMU, WLAN, BLE, 5G Fingerprinting**
- **Fine-grained Localization & Pose Tracking**
  - Natural Feature Tracking (NFT)-based **feature tracking**
  - YOLOv5 **door detection**
  - Camera alignment with **BIM models**
- **5G-Based AR Streaming**
  - Cloud offloading of **compute-heavy tasks and large data**
  - Low-latency **real-time visualization**



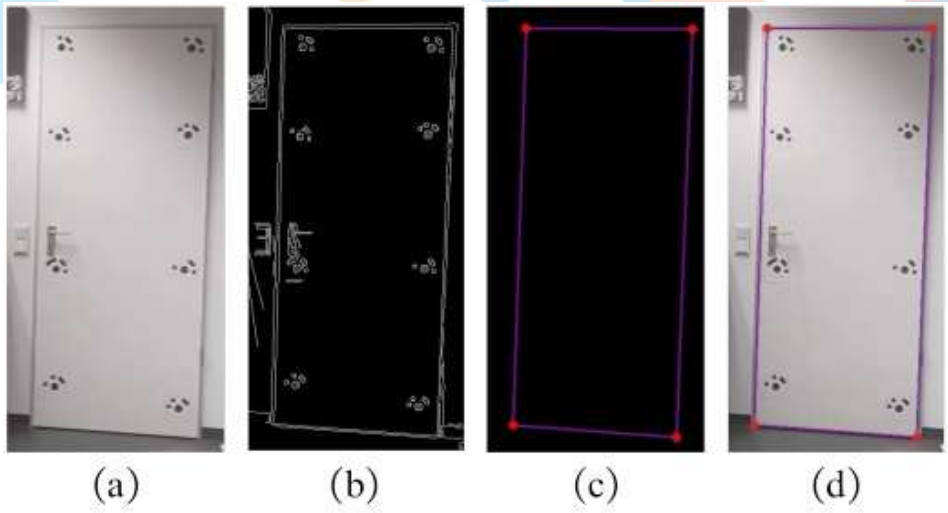
System Components – Coarse Indoor Positioning

- **Objective:**
  - Provide an initial **room-level localization** (GNSS indoors not available)
- **Technology:**
  - **IMU (Acceleration, Gyroscope, Magnetometer)**
  - **WLAN, BLE, 5G Fingerprinting (to be integrated)**
- **Methods:**
  - Use **sensor fusion** to improve robustness
  - **Grid-based particle filter for probability-based localization**
- **Outcome:**
  - **Reliable indoor positioning independent of GNSS**



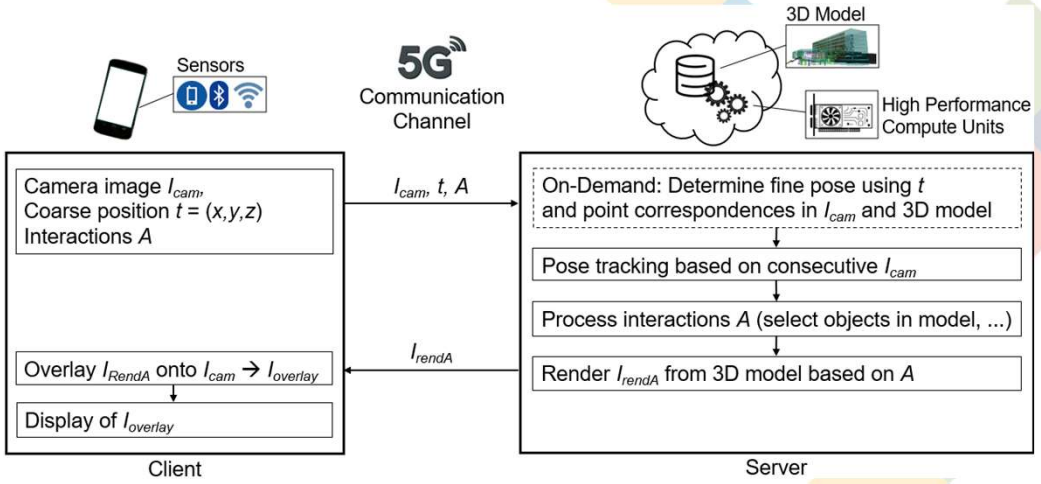
System Components – Fine-grained Localization & Pose Tracking

- **Objective:**
  - Improve **positioning accuracy** after coarse localization
  - Enable **precise AR overlay alignment** with real-world structures
- **Methods:**
  - **NFT** for detecting building features
  - **YOLOv5 for door detection** as reference points
  - **Perspective-n-Point (PnP) algorithm** for fine pose estimation
- **Outcome:**
  - **Accurate device orientation & spatial alignment of AR content**



System Components – 5G-Based AR Streaming

- Objective:
  - Outsourcing of computationally intensive tasks and large amounts of data to a server
  - Ensure **low-latency real-time visualization**
- Technology:
  - **5G for fast data transmission (to be integrated)**
  - **Cloud-based processing** for large **BIM models**
  - **Streaming of AR content to mobile devices**
  - **Unreal Engine with Pixel Streaming**
- Outcome:
  - **Real-time AR overlays with minimal latency**



Experimental Evaluation – Key Results

- **Coarse Indoor Positioning:**
  - **Median error: 1.05 m**, **RMSE: 1.51 m**, **95th percentile error: ≤ 3.26 m**
  - Sensor fusion achieves **reliable sub-2m localization accuracy**
- **Fine Localization & Pose Tracking:**
  - **Translation error: Few centimeters**
  - **Rotation error: Below 5°**
  - Ensures **precise spatial alignment** for AR overlays
- **5G-Based AR Streaming:**
  - **Evaluation based on WLAN network**
  - **Smooth rendering**, **minimal delay** (on iPhone 13)
  - **30 FPS** (Server-side Overlay), **20-21 FPS** (Client-side Overlay)

Conclusion and Future Work

- Key Takeaways:
  - 5G + AR + Sensor Fusion enables real-time location-aware assistance
  - Low-latency cloud-based AR streaming supports real-time visualization
- Future Work:
  - Full-scale 5G network integration
  - Integration of real-time IoT sensor data for advanced monitoring
  - Performance evaluation under real-world conditions

The most relevant SDGs related to the presentation and theme of this session

1st relevant SDG

2nd relevant SDG

3rd relevant SDG

SUSTAINABLE DEVELOPMENT GOALS

International Federation of Surveyors supports the Sustainable Development Goals