Privacy preserving camera system
embedded in a Digital Twin environment

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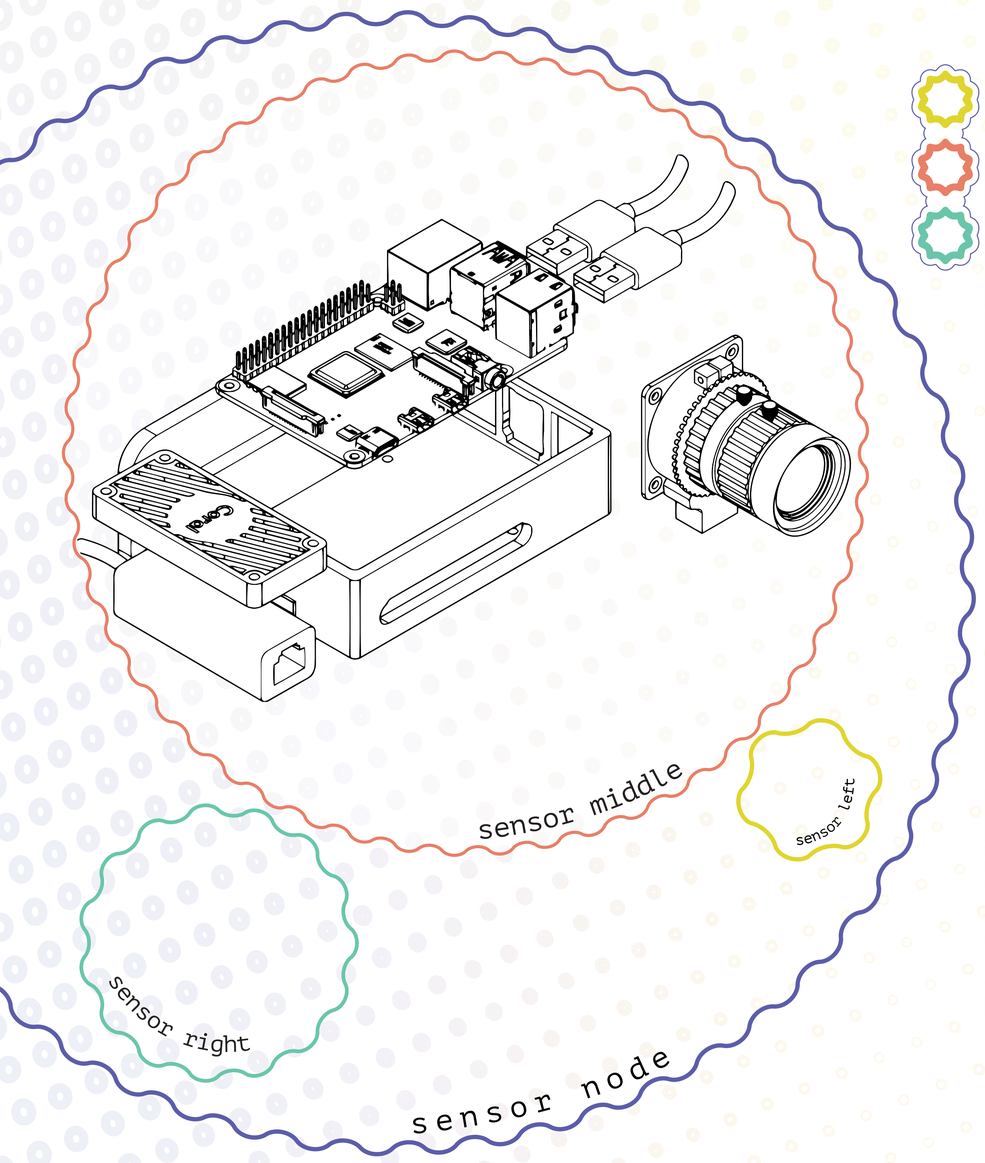
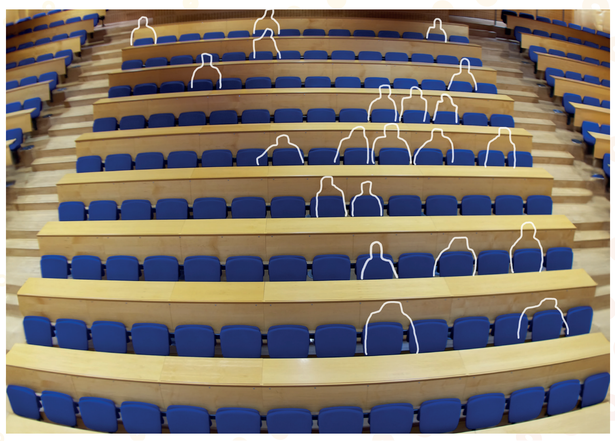
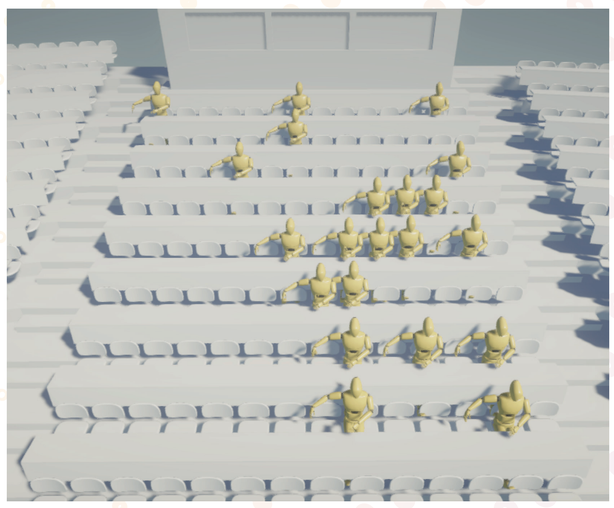


Lecture Theatre 1 in the William Gates Building. The three privacy preserving cameras were placed as indicated.

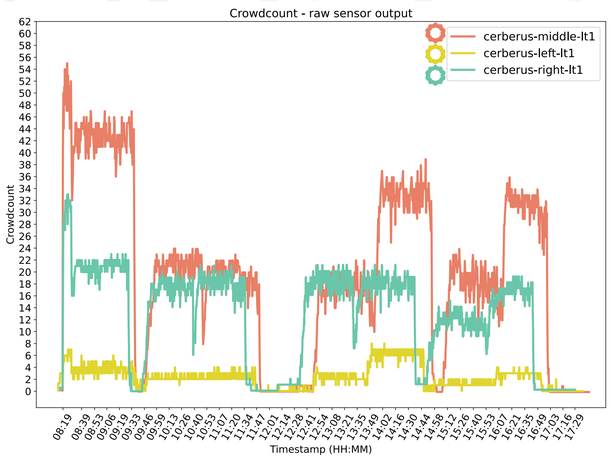


View as seen from the middle camera. Captured photos never leave the sensor system, making it privacy preserving.

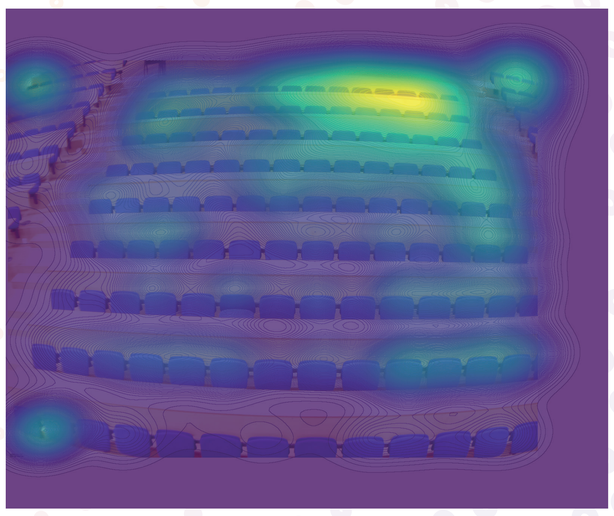


Unity-rendered digital twin displaying real-time camera sensor data for building occupancy monitoring. The static avatars are placed where people sit in the actual lecture theatre.

Unity-rendered digital twin with animated avatars, driven by environmental data and sensor detections for dynamic building occupancy monitoring. Green particles represent exhaled CO_2.



Line plot displaying crowd count data collected throughout an entire day from three sensor cameras, providing insights into daily occupancy variations and sensor reliability.



Long-term sitting patterns visualized using KDE plots.

real-time animation

raw sensor crowdcount

cyberphysical site

camera view

digital twin view

long-term analysis

camera node results

00 Objective

Real-time, privacy-preserving seat occupancy monitoring system using Raspberry Pi 4 and face detection algorithms.

Accurate building occupancy monitoring aids disease mitigation and facility management; existing solutions lack scalability.

01 Sensor System

System Architecture

Hardware: Raspberry Pi 4 with wide-angle lenses, positioned to cover the entire lecture theatre.

Software: Onboard edge computing for face detection (sensor) and asynschronous data analysis (node).

Machine Learning Models

Multi-Modal Face Detection: Different models (e.g., Yoloface v5, YuNet, RetinaFace) running sequentially or in parallel.

Data Streaming

MQTT Broker: For asynchronous data transmission to the Adaptive City Platform.

Real-time and Event-Based: Data sent periodically and/or triggered by specific events.

Data is processed on the edge to ensure privacy and efficiency.

02 Data Visualisation

Short Term

Moving animations in Unity represent real-time seat occupancy and environmental conditions. Animations could also be tied to specific environmental criteria or student attentiveness, offering a spatiotemporal visualisation.

Long Term

Kernel Density Estimation (KDE) plots provide an aggregate, long-term view of seat occupancy, facilitating trend analysis and strategic decision-making.

03 Summary

Our privacy-preserving system enables real-time crowd analytics. The tri-camera node setup feeds into a sensor-embedded digital twin, offering critical behavioral insights.