Milesight

Breathing Easy and Enhancing Indoor Air Quality with LoRaWAN® Innovations

Hong Kong, China

Success Story

Milesight Partner	Location	Number of Devices Deployed	Applications
Dr. Amos Darko, Assistant Professor, Department of Construction Management, University of Washington	The Hong Kong Polytech University, China	3 * AM307 7-in-1 IAQ Sensor 1 * UG65 Semi-industrial LoRaWAN® Gateway	Smart Indoor Air Quality Monitoring Enhance Occupants' Health and Wellbeings Improved IEQ Monitoring and Assessment

Papers & Honors

At Milesight, we believe in the power of relevant, purposeful sensing, focusing on the data that adds value, reflects patterns, and assists decision-making. We are also delighted to collaborate with professionals on research and on-field experiments, working with them to make the world a better place.

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Among Milesight's collaborations with all the great professionals around the world, in Hong Kong, China, and the U.S., we have a close relationship with Dr. Amos Darko and his research teams on projects related to building sustainability, digitalization, and management. From September 2022 to the present, Dr. Amos Darko's team has been working on indoor space research, using Milesight IAQ sensors and gateways for data collection and analysis.

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In 2023, Dr. Amos Darko and his team were awarded the Best Paper Award in the stream Advanced Technologies & Innovations in Building/Construction at the 46th Australasian Universities Building Education Association (AUBEA) 2023 Conference in recognition of their winning entry "Digital Twinning of Existing Indoor Space for Improved Indoor Environmental Quality Monitoring and Assessment".

03

Conference Papers / Book Chapters

Darko, A., Jayasanka, T.A.D.K., Chan, A.P.C., Jalaei, F., Ansah, M.K., Opoku, DG.J. (2024). Digital Twin-Based Automated Green Building Assessment Framework. In: Skatulla, S., Beushausen, H. (eds) Advances in Information Technology in Civil and Building Engineering. ICCCBE 2022. Lecture Notes in Civil Engineering, vol 357. Springer, Cham

T.A.D.K. Jayasanka, Amos Darko, Farzad Jalaei, Albert P.C. Chan, Digital Twinning of Existing Indoor Space for Improved Indoor Environmental Quality Monitoring and Assessment, the 46th Australasian Universities Building Education Association (AUBEA), 2023 Conference

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More details >

Honors and Awards

The Best Paper Award in the stream Advanced Technologies & Innovations in Building/Construction at the 46th Australasian Universities Building Education Association (AUBEA) 2023 Conference in recognition of the winning entry "Digital Twinning of Existing Indoor Space for Improved Indoor Environmental Quality Monitoring and Assessment"

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More details >

Background

The long-lasting effects of the COVID-19 crisis have triggered the significance of indoor environmental quality (IEQ). Also, over 90% of a human's life is spent indoors. Therefore, it's important that indoor environments promote human-centricity to enhance occupants' health and wellbeing, comfort, productivity, happiness, and quality of life. A high-quality indoor environment can be achieved by improved IEQ monitoring and assessment. There are several challenges to achieving improved IEQ monitoring and assessment of existing indoor spaces.

- Agility of buildings
- Complex indoor designs
- Dynamic natural environments
- Personalized indoor cooling and heating

These challenges cause heterogeneities and unpredictability of IEQ parameters even within the same indoor space and a certain timestamp. Therefore, improved IEQ monitoring and assessment should be spatiotemporal, and real-time in both space and time. Additionally, in line with building sustainability assessment systems and building standards, it is important to collect objective measurements rather than subjective ones.

In this context, a digital twin is an up-to-date digital representation of an intended or actual real-world physical entity, hence digital twins of indoor spaces can provide objective, spatiotemporal data in real-time in both space and time for improved IEQ monitoring and assessment. The aim of the project is to develop a digital twin of existing indoor spaces for improved IEQ monitoring and assessment.

Challenges

Implementation of sensor systems and building information modeling (BIM) models are key to developing digital twins for buildings. Sensor systems can provide real-time sensor data of environmental parameters while BIM model provides building information as digital 3D models.

However, there are challenges in creating digital twins for existing indoor spaces, mainly including,

Successfully creating BIM models of indoor spaces for digital twin

- How to collect accurate as-is building data from indoor spaces.
- How to efficiently develop as-is BIM models of indoor spaces.
- Developing an accurate, user-friendly, and scalable sensing system to provide environmental data for digital twins.

Developing an accurate, user-friendly, and scalable sensing system to provide environmental data for digital twins.

- How to collect spatiotemporal environmental data to represent the entire indoor space.
- Recent research revealed that higher air pollutant levels viz. PM2.5 and CO, along with temperature and humidity increase COVID-19 risk. It is crucial to collect and analyze IEQ parameters' data simultaneously to identify potential health risks. Therefore, how to collect and analyze IEQ parameters' data simultaneously from each sample point.
- How to easily deploy a cost-effective, user-friendly, and scalable sensing system.

Integrating data from the BIM model and the sensing system

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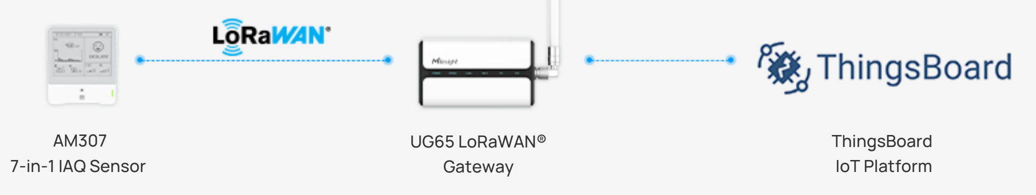
Project

In response to the challenges in creating digital twins for improved IEQ monitoring and assessment, the project develops a comprehensive approach to creating digital twins for existing indoor spaces.



AM307 7-in-1 IAQ Sensor | UG65 LoRaWAN® Gateway | ThingsBoard IoT Platform

As the first step, the partner proposes a well-planned Internet of Things (IoT) sensor deployment for capturing real-time spatiotemporal data.

IoT sensor deployment includes four layers. Sensors in the sensing layer, are placed at multiple sample points. Users use battery-powered sensors which are highly sensitive, easy to deploy, portable, and flexible. Also, the partner proposed to use multi-parameter sensors that can collect data for several IEQ parameters at the same timestamp to make more accurate decisions on indoor air pollution and related health risks.

Considering communication patterns of the IoT edge devices, throughput and range requirements, and impact on existing IT infrastructure, LoRaWAN is selected as the network protocol for our method. Compared with other wireless data transmission technologies, LoRaWAN provides a greater communication range with low bandwidth.

IoT applications that need to connect remote embedded sensors and machine-to-machine interactions can use Messaging Queue Telemetry (MQTT), an open-source lightweight messaging protocol. Hence, the project used MQTT to facilitate message exchange in the network and communication layer.

A NoSQL, time-series database is used to store data for the proposed method. The user proposed to select a cloud service provider to host the database. This allows the processing of large amounts of data and ensures the greater scalability of the data streaming infrastructure of this IoT deployment. In the application layer, we develop a dashboard to real-time visualize the sensor data remotely.

The second step is implementing an integrated technique of laser scanning-FM information to capture the as-is physical condition of the indoor space.

The users use laser scans to capture the geometric data as 3D point cloud data. Laser scanning is an efficient technique for capturing the as-is physical condition of an indoor space to create an as-is 3D BIM model, which is much more accurate than using initial design data to create a 3D BIM model of an existing indoor space.

Then, a data cleaning and registration process transforms collected geometric data into geometric information.

Laser scanning alone could not capture semantic information. Hence, the required semantic information for the 3D BIM model can be extracted from pre-existing (specifications and building materials) building information. Such information is obtained from the FM office.

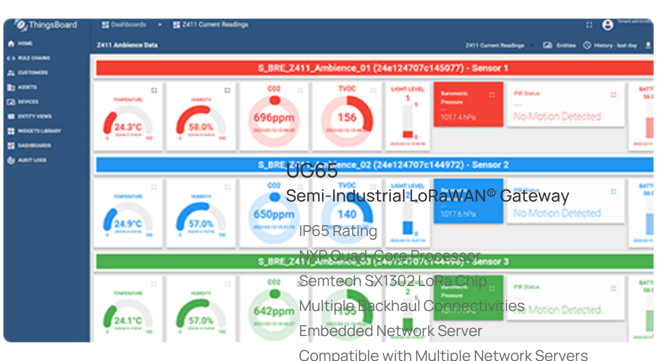
This geometric and semantic information is used to create building objects. 3D, as-is representation of the indoor space is achieved upon recognizing and classifying objects to create a precise and complete as-is 3D BIM model.

Finally, the professor proposes a cloud-based data integration platform that streams data in real-time to power the DT, avoiding the limitations of previous desktop-based data integration methods.

The proposed solution was operationalized in a real-world setting in a Hong Kong Polytechnic University classroom, when the partner was a Research Assistant Professor at this university before joining the University of Washington. The partner installed three Milesight AM307 sensor devices to measure temperature, humidity, light, motion, CO2, TVOC, and pressure.

Milesight AM307 sensor devices were placed at three targeted locations following the targeted placement strategy.

- Occupant areas were considered to ensure that sensors accurately measure the indoor environment experienced by occupants.
- The location of the air supply from the ventilation system in the classroom was considered since it helps to monitor the air being supplied.
- The locations of windows and doors were also considered as they are frequently opened or if there is a risk of external pollutants entering the classroom.



One of the main advantages of AM307 as a multi-parameter sensor device is, for example, the placement for temperature and humidity sensors is designed to isolate the heat generated when the device is operating. It provides higher accuracy for measurements. It is battery-powered and can also be powered via Type-C. In the classroom, the partner placed a Milesight UG65 LoRaWAN gateway that is compatible with AM307 sensors. UG65 LoRaWAN gateway can handle a higher amount of traffic with lower power consumption.

Among all other NoSQL databases, InfluxDB time-series database is well recognized for IoT sensor data storing due to its usage, and efficient query performance. Therefore, we configured InfluxDBCloud as the database service for the proposed model. It is hosted on Azure cloud and can handle large amounts of IoT data. Then dashboard was developed by using ThingsBoard IoT platform to visualize the sensor data.

The partner fully adopted the laser scanning technique for developing the geometric digital twin instant of the classroom. In the modeling process, as-is measurements were totally based on scanned 3D point cloud data captured from the latest and fastest FARO Focus Premium Laser Scanner instead of previous drawings records. The resulting 3D point cloud data was cleaned and registered automatically using Autodesk ReCap, a reality capture software. Then the partner used Autodesk Revit and spectral information from the facility management office for BIM modeling.

One critical step is retrieving IEQ IoT sensor data from InfluxDBCloud to geometric digital twin instant for creating a digital twin. The solution designer used the Data Visualization Extension offered by Autodesk Platform Services (APS) for geometric digital twin instant and IEQ IoT sensor data integration.

Results

This project has two significant implications. This project demonstrates both the aspirations and technological readiness for overcoming the limitations of

Previous IEQ monitoring and assessment approaches such as isolated, single parameters, stationary sensor approach, mobile sensors carts and mobile sensors robots, design approaches, historical data approach, and crowdsourcing approaches.

Identifying the ineffectiveness of IoT deployments with traditional isolated single-parameter sensors and addressing the raising requirements of health and safety aspects related to IEQ, the proposed method demonstrates the use of multi-parameter sensors to capture IEQ parameters both spatially and temporally in real-time for digital twins.

Real-time data can be visualized in the developed digital twin, which can be simply used for more accurate IEQ assessment under building sustainability assessment systems compared to employing unreliable design approaches or using historical data.

In terms of visualization capabilities such as visualizing: multi-parameter sensor values at the same timestamp, time-series graphs that can identify meaningful statistical characteristics (trends) and leverage forecasting models, heatmaps, and building assets and elements search within DT are significant enhancement of the proposed DT approach over any other existing IEQ monitoring and assessment approaches such as navigation-enable, sensing-capable, mobile robots for IEQ monitoring and assessment.

In future deployment, this digital twin can be integrated with subjective data related to IEQ that can be collected from a crowdsourcing approach to further enhancements of IEQ monitoring and assessment via the DT approach.

Previous DT creation methods for IEQ monitoring and assessment.

The proposed IoT deployment was designed by comparing the options available at each layer of the IoT deployment to ensure the efficiency, accuracy, and cost-effectiveness of DT in performing IEQ monitoring and assessment. The proposed method highlighted the use of battery-powered, multi-parameter sensors at multiple sample points to collect spatiotemporal, real-time data which is crucial for improved IEQ monitoring and assessment while significantly reducing the cost of the IoT deployment (cost of three Milesight AM307 sensors with UG65 LoRaWAN gateway is about 1000 USD).

This study emphasizes the importance of employing time-series, cloud-based databases that are scalable and ideal for real-time sensor data streams for IoT deployments in creating DTs.

For the first time in creating DT of existing indoor space for IEQ monitoring and assessment, we created a geometric digital twin demonstrating the implementation procedure of an integrated technique of laser scanning-FM information with BIM. The proposed method for creating a geometric digital twin is less liable to human errors, and saves substantial labor hours over manual BIM modeling.

The geometric digital twin prototype development was carried out through the case study implementation and successfully verified by comparing the temperature, humidity, TVOC, and CO2 measurements in InfluxDBCloud and data visualizing in the digital twin.

Created digital twin updates spatiotemporal data of IEQ parameters in real-time and visualizes them in a user-friendly manner incorporating sensor value tables, time-series graphs and heatmaps.

Partner

Dr. Amos Darko is an Assistant Professor in the Department of Construction Management at the University of Washington, Seattle, WA, USA. He earned his Ph.D. degree from The Hong Kong Polytechnic University (PolyU) in 2019, and his BSc degree (First Class Honors) from Kwame Nkrumah University of Science and Technology (KNUST) in 2014. Before joining the University of Washington, Dr. Darko was a Research Assistant Professor at PolyU. Dr. Darko has also worked as a Postdoctoral Fellow and as a Research and Teaching Assistant at PolyU and KNUST, respectively. Dr. Darko has published numerous papers in leading international peer-reviewed journals, conferences, and books. His papers have been rated as highly cited and hot papers by the Web of Science. His paper is the most cited paper of all time in the International Journal of Construction Management. He is an Associate Editor of Green Building and Construction Economics, an Associate Editor of Humanities and Social Sciences Communications, an Academic Editor of Advances in Civil Engineering, and member of editorial boards of other international peer-reviewed journals. Dr. Darko is also an active reviewer for several international peer-reviewed journals....

About Dr. Amos Darko

Why Choose Milesight

A sensing system deployed for building digital twin implementation is critical. Because it is specifically developed to collect real-time, dynamic, spatiotemporal building's behavioral profile from the physical building to integrate mainly with the 3D BIM model and update the digital twin.

We have selected Milesight AM307 sensor devices for the following reasons:

Milesight AM307 sensor devices are multi-parameter sensors. Multi-parameter sensors can measure parameters simultaneously, providing a more holistic understanding of the building behavior than single-parameter sensors

Milesight AM307 sensor devices are portable and can be wall-mounted, hence easy to place. The proper sensor placement ensures that the sensors capture spatiotemporal data from the physical building for creating a reliable and valid digital twin that accurately reflects real-world dynamic building behavior.

Milesight AM307 sensor devices are ready-to-use sensor devices. The development of a sensing system using development boards such as Raspberry Pi, Arduino and DAQ hardware requires technical knowledge in terms of installing an operating system, configuring the software, and connecting the appropriate sensors. Therefore, the configuration process is more complex for non-expertise without prior knowledge or experience. However, overcoming the above limitation, we proposed to use Milesight AM307 sensor devices which are ready-to-use, dedicated sensor devices.

Milesight UG65 LoRaWAN gateway that is compatible with AM307 sensor devices. In contrast to Zigbee, BLE and Wi-Fi, Long Range Wide Area Network (LoRaWAN) has a significantly longer range, consumes very low power, supports massive scalability, allowing for many devices to be connected to the network, and has better signal penetration capabilities. Therefore, the we used a Milesight UG65 LoRaWAN gateway.

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Tel: +86-592-5085280 | Email: iot.sales@milesight.com | Web: www.milesight.com

Address: Building C09, Software Park Phase III Xiamen, Fujian, China