Air Quality Monitoring Platform for Virtual Reality-Enabled Digital Twin: the use case of Cartagena (Spain)

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smartDUMP

Índice

Introduction

Why is it important to monitor air quality?

- Health
- Regulations
- Visibility

Particulate Matter	Cause
$PM_{1.0}$	Coal combustion, soil dust, vehicle exhaust.
$PM_{2.5}$	Emissions from combustion of gasoline, oil, diesel or Wood.
PM_{10}	Combustion and dust from construction sites, landfills, agriculture, wildfires, brush/waste burning, industrial sources, wind-blown dust or pollen.

Why is it important to monitor air quality?

Gases	Cause	Effect
SO_2	Released from coal and oil combustion.	Can lead to respiratory diseases and even death.
NO_2	Produced by road traffic and other fossil fuel combustion processes.	It contributes to acid rain and can lead to pulmonary irritation.
CO	It is released from the combustion of wood, oil, charcoal, and natural gas.	It is linked to headaches, breathing difficulties, loss of consciousness and even death.
O_3	Originates from the chemical reaction between sunlight and the pollutant from vehicles and industries.	It can lead to breathing difficulties, respiratory infections, or premature death.

What can we use these data for?

- Health warnings
- Urban planing

- Manage traffic
- Real estate

- Detect pollution sources

- The presence of air monitoring devices in cities is increasing.

- Data is usually not accessible.

Digital Twins

- Digital Twins enable the creation of digital replicas of the physical world that can be used for real-time monitoring.

  - Object
  - Building
  - City

- City-level digital twin introduce new challenges.
  - More complexity.
  - Difficult to scale.

- We present a digital twin of a smart city for air quality monitoring enabled by virtual-reality.

Related Work

- Currently existing digital twins focus on buildings and monitoring the physical factors that affect them (structure, lighting, plumbing, etc.) or the people inhabiting them (indoor temperatura, humidity, etc.).

- City-scale digital twins have begun to be developed as well for weather monitoring, traffic monitoring, and emergency management.

- Some of the air-quality related proposals focused on indoor environments, while others provided a city-scale solution using mixed reality or 2D representations.

- Instead of focusing on building-scale digital twins or 2D representations, we present a city-scale 3D digital twin for outdoor air quality monitoring enabled by virtual reality.
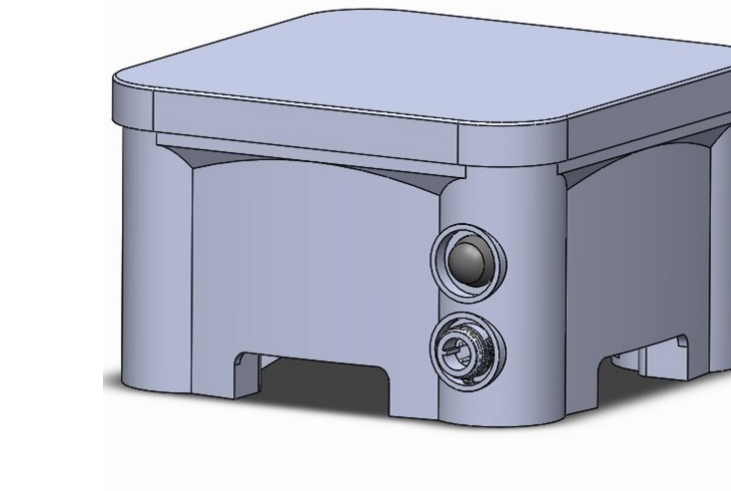
Methodology

Architecture
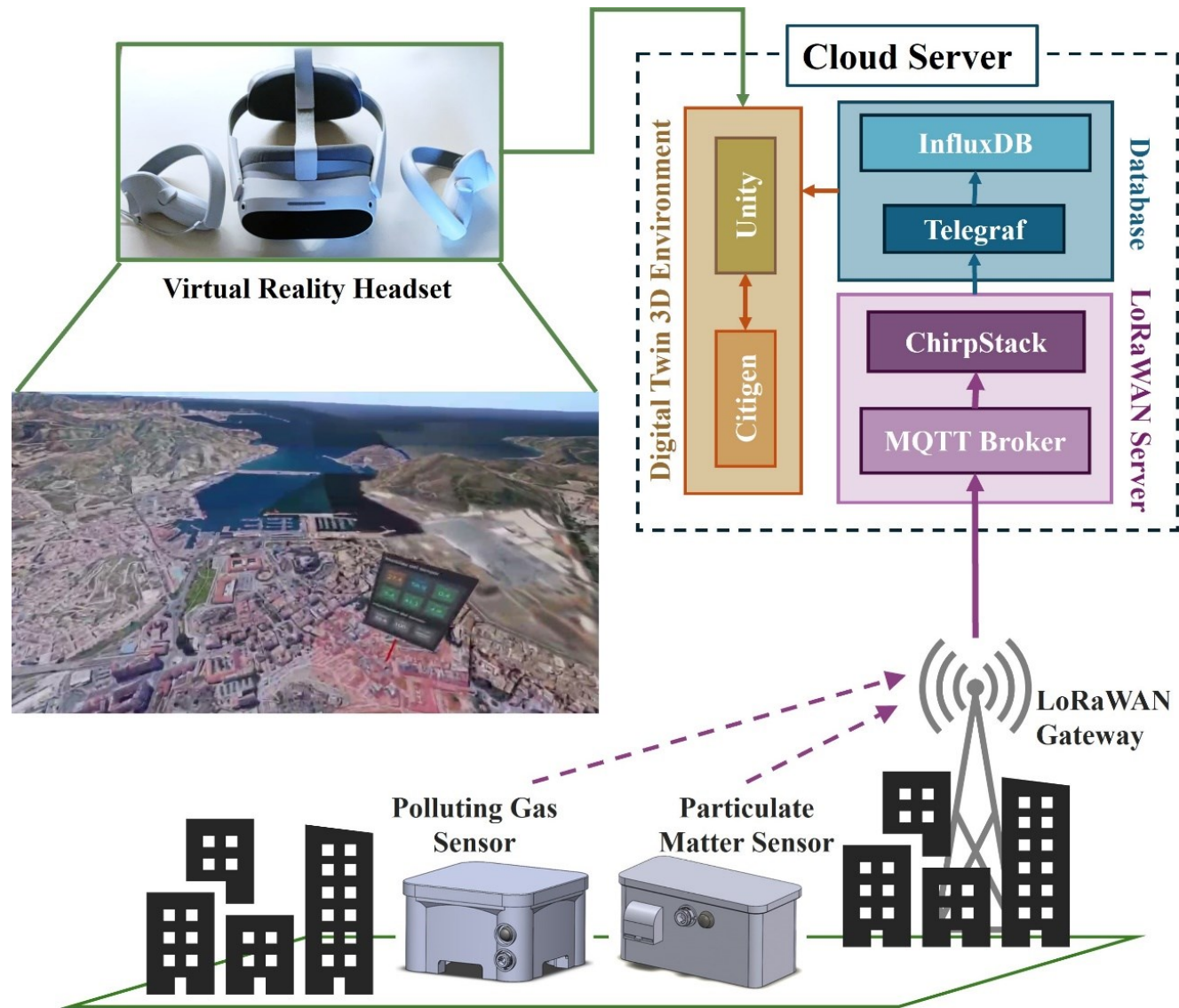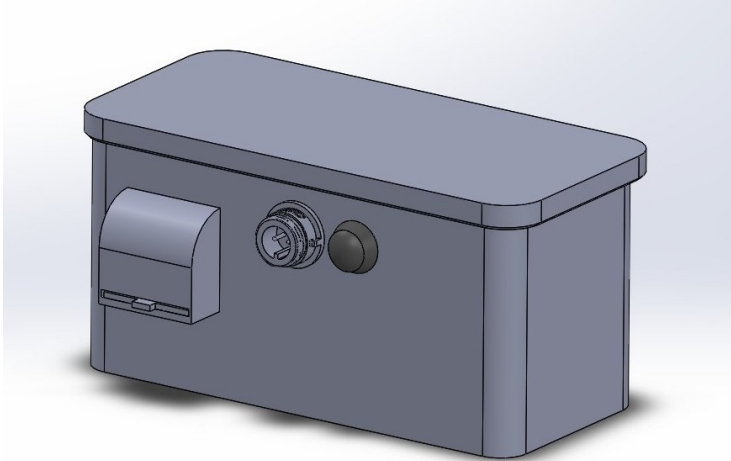
Suspended Particulate Matter

PM10, PM2.5, and PM1.0.

Wireless communication over LoRaWAN.

GPS.

Polluting Gasses

SO2, NO2, O3, and CO.
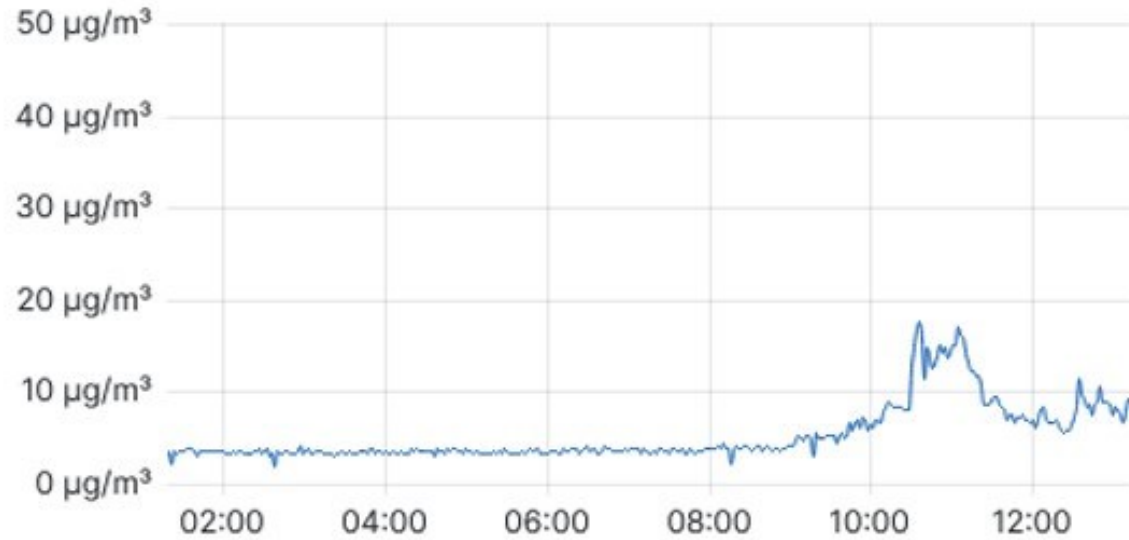
Wireless communication over LoRaWAN.

GPS.

- Installed in streetlamps.

- Anti-vandal support casing.

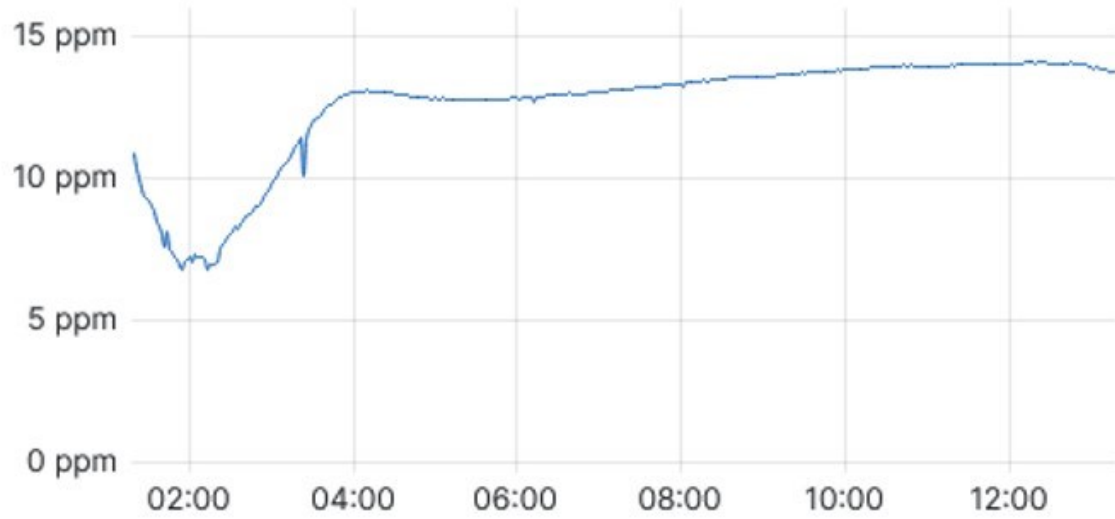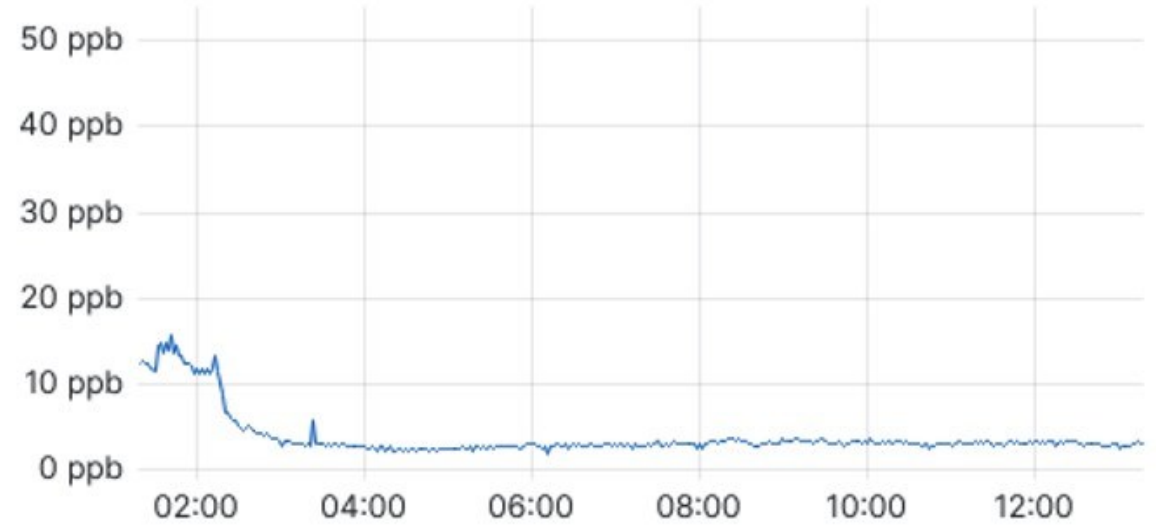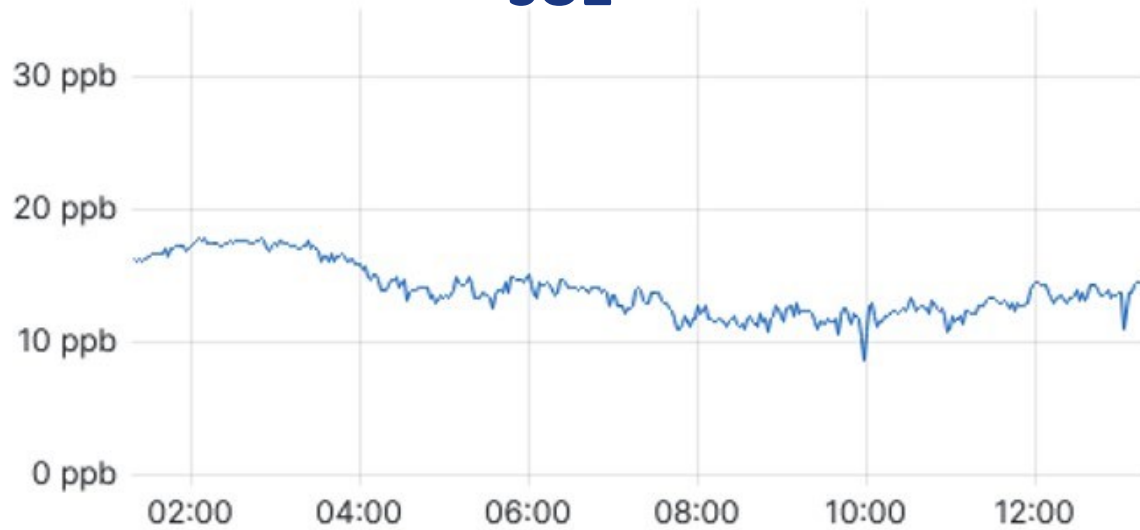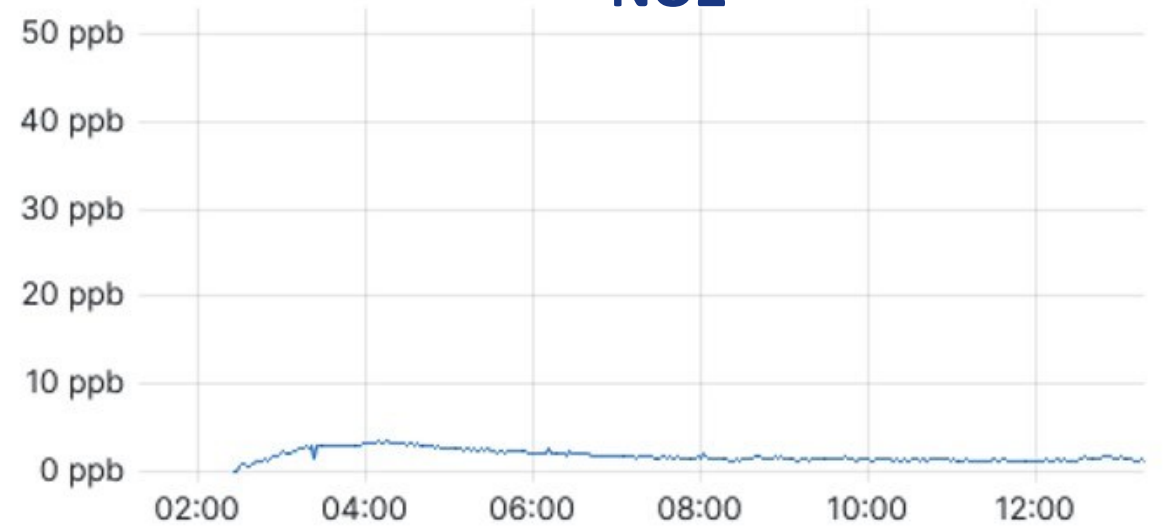- More than one year in operation and under adverse weather conditions, without requiring maintenance yet.

Pico 4 VR Headset

Snapdragon XR2 processor.

8 GB of RAM and 128 GB of storage.

WiFi 6 and Bluetooth 5.1.

1200 PPI pixel density.

50 dB echo cancellation.

Quest 2 VR headset

Snapdragon XR2 processor.

6 GB of RAM and 256 GB of storage.

WiFi 6

1100 PPI pixel density.

45 dB echo cancellation.

Unity

- Unity is a game development engine that enables the creation of games, interactive simulations, virtual reality (VR) and augmented reality experiences, and 2D and 3D applications.

- The Key aspects for the development of our digital twin were:

  - Height map to consider the angle of the viewer with the surface.

  - Texture compression improved processing times.

Unity

- Use of reduced number of baked lights (used for ambience lighting) to reduce the computational cost of rendering the scene.

- Wireframe mode modifies the levels of detail depending on the distance of the object to adjust the number of polygons to optimize the scene.

- Occlusion Culling prevents Unity from loading objects outside the camera view. Must be done for each object in the city plan.
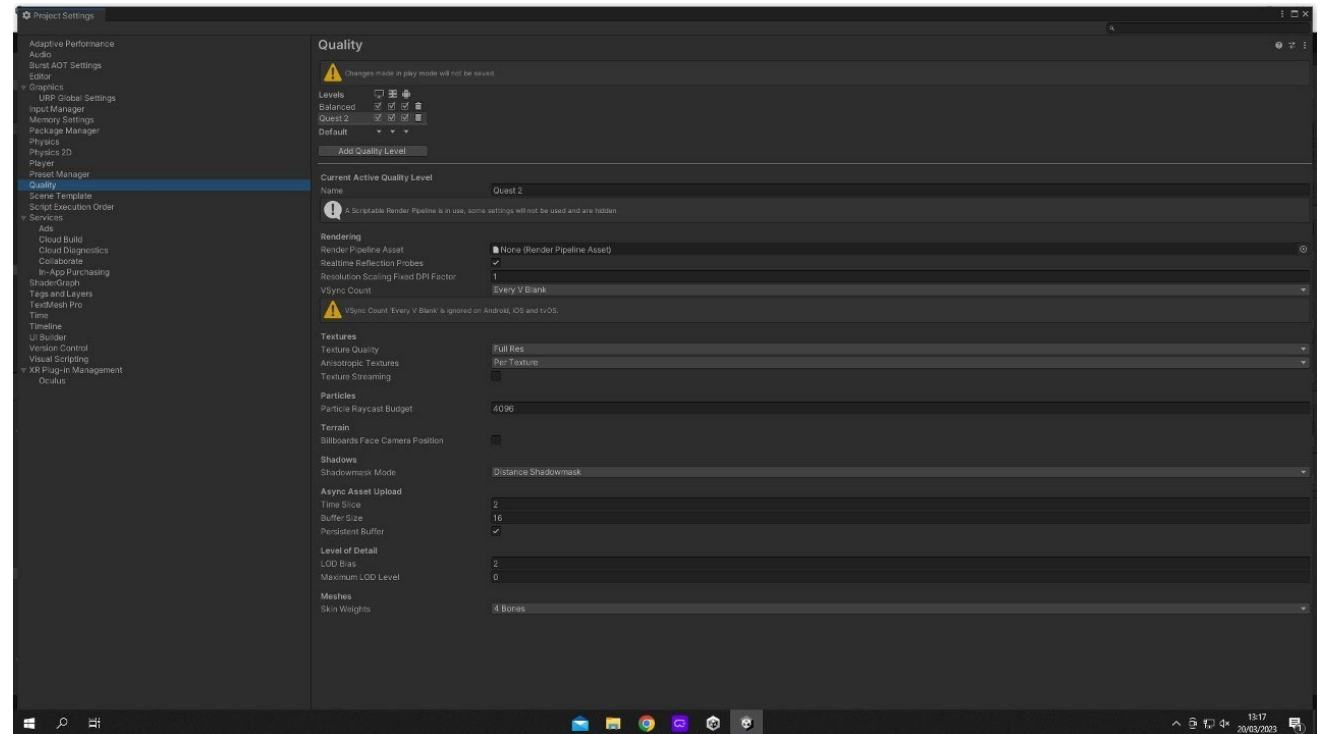
Unity

- Objects were included to display the individual information of each sensor stored at InfluxDB.

- A first object is added at the position where the sensor is located in the real world.

- Clicking the object opens a screen to view the information, which is represented as an object added inside the screen.

- The object is comprised of several sections including temperature, humidity, CO, NO2, O3 and SO2 for the polluting gas sensor device.

Citigen3D

- CityGen3D is an extension for the Unity editor designed to simplify the automated creation of three-dimensional scenarios based on real-world map data.

- Adding textures help in making the world more realistic.

- Most trees were eliminated to save rendering memory.

Results

Digital twin using VR headset

Digital twin using VR headset

Conclusión

- Smart cities are viewing digital twins as a tool to provide accessible information to its citizens.

- This paper showed the implementation of our digital twin for air quality monitoring in the city of Cartagena (Spain), which can display the data gathered from polluting gas and suspended particulate matter sensors at different locations of the digital twin map.

- It is enhanced by virtual reality, providing an immersive experience for the user.

- The growing interest in this technologies has led to conversations with several institutions, where the identified applications of the digital twin were not limited to data visualization, but also allows for helping policy-makers in performing informed decisions on redirecting traffic flows and urban planning.

Thank you!