

Photovoltaic Digital Twins using Game Engine Simulations

Madara Premawardhana and Harin Sellahewa
School of Computing, University of Buckingham, United Kingdom



THE UNIVERSITY OF
BUCKINGHAM

1. Introduction

Digital Twins, virtual replicas of real-world systems (Grieves, 2016), can optimise performance and support predictive maintenance for renewable energy resources. This research explores the application of Unreal Engine in creating Digital Twins of Photovoltaic (PV) Solar systems. By utilising game engines, which offer real-time interactivity, high-performance simulation, and advanced visualisation, this approach overcomes the limitations of traditional Digital Twin tools, such as limited customisation, scalability challenges, and inadequate integration with dynamic environmental factors.

2. Methodology

A Digital Twin model for a PV solar panel system was developed using Unreal Engine. Figure 1 illustrates its main components.

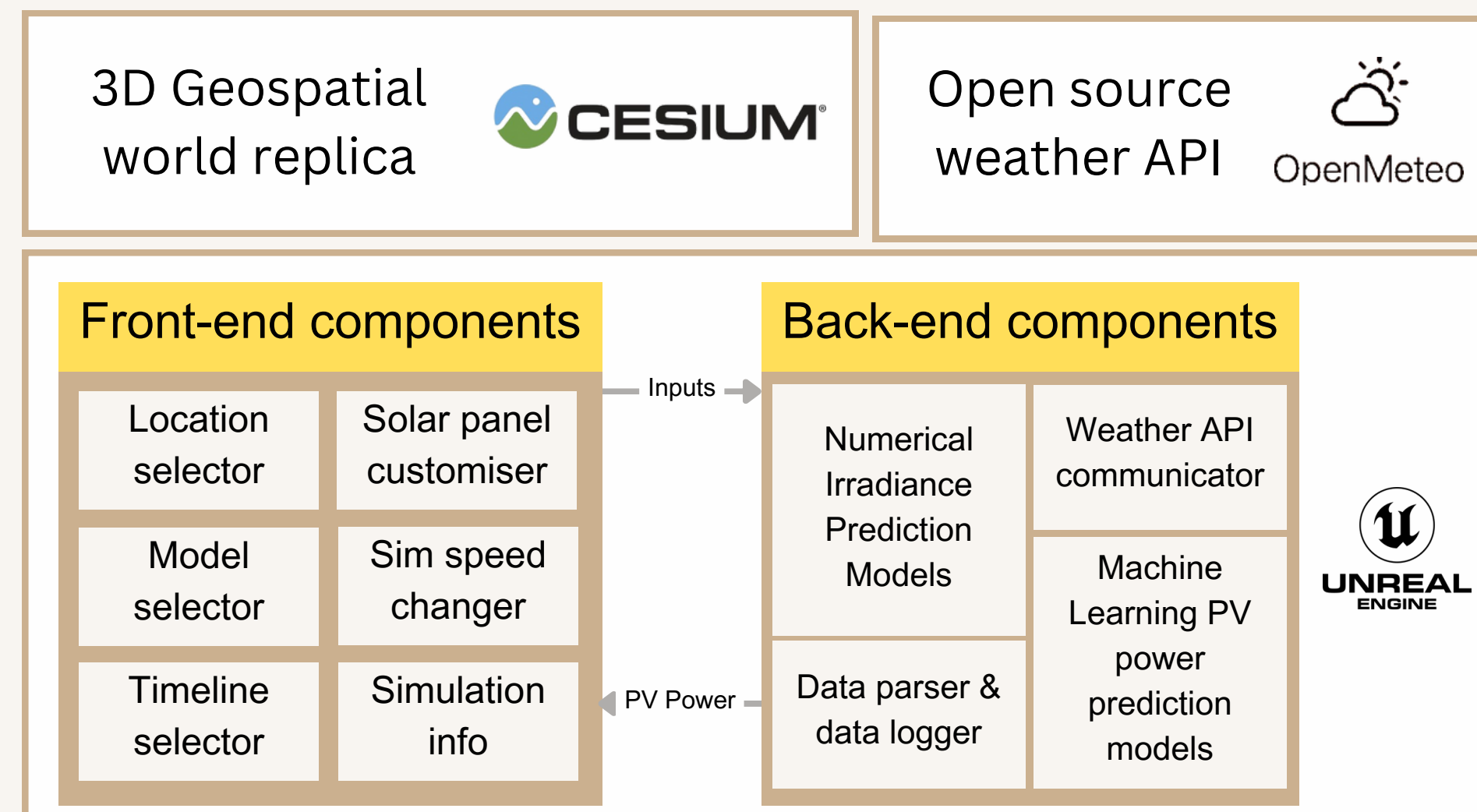


Figure 1: Components of the PV Digital Twin

This system can replicate PV Digital Twins allowing user customisation. The Digital Twin can be simulated throughout a set time period, for a selected location. System also replicate dynamically changing weather in the hosted simulation environment while allowing user to speed up simulation. Photovoltaic power gets calculated by the Digital Twin embedded models, taking intermittent weather changes into consideration.

3. Results

The Digital Twin effectively simulated solar energy production under different weather conditions. It adapted to changes in location, shadows from obstructions, panel orientations, and the set specifications such as panel efficiency. This provided highly accurate insights for optimisation and grid integration. Figure 2 shows a snapshot of the simulation running in a real-world location. The yellow line traces the sun's position in the 3D world. The simulation also showed how solar energy output changes with variations in weather and location.

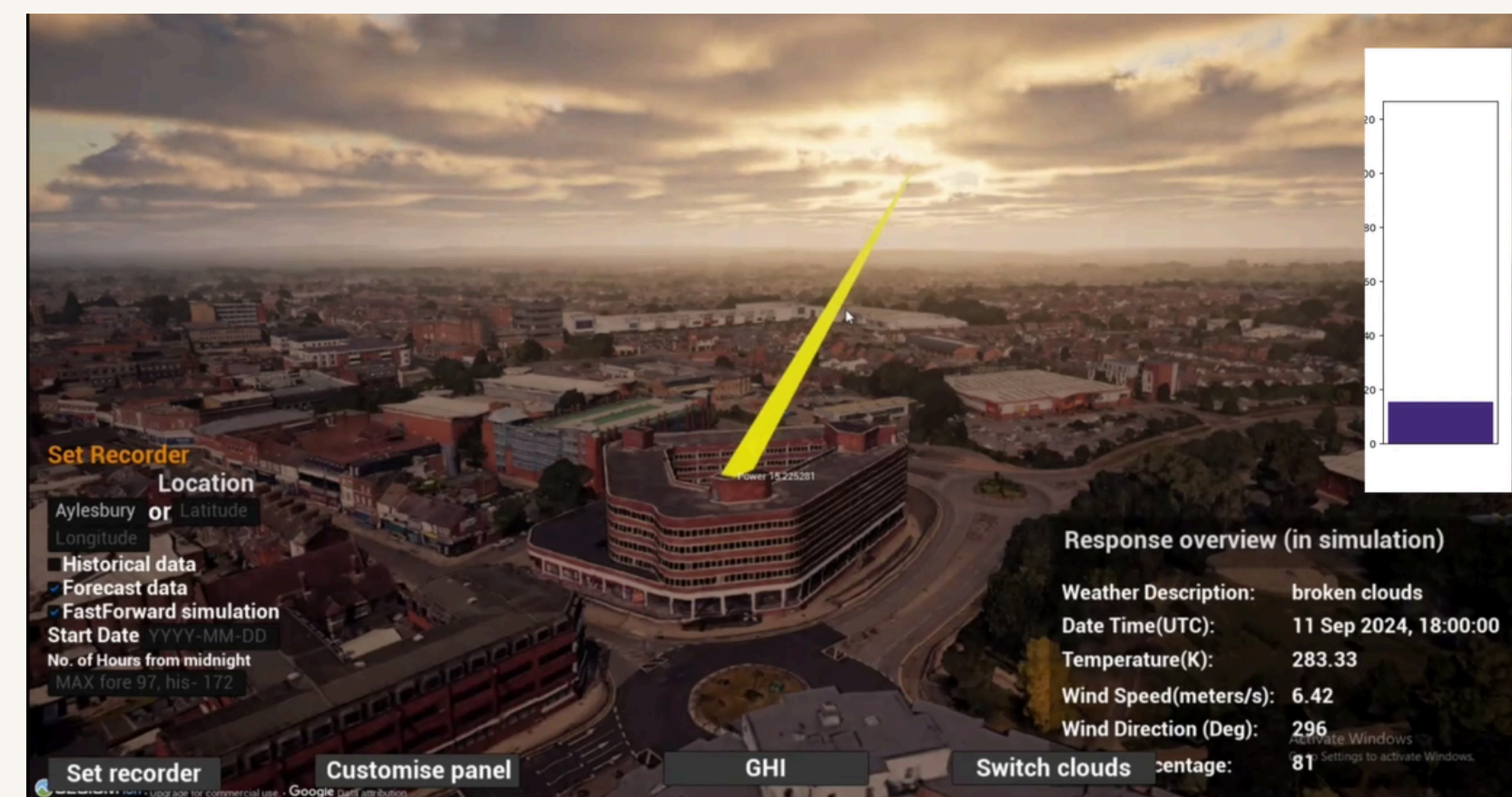


Figure 2: Photovoltaic Digital Twin placed and simulated at Aylesbury, UK integrating real-time weather

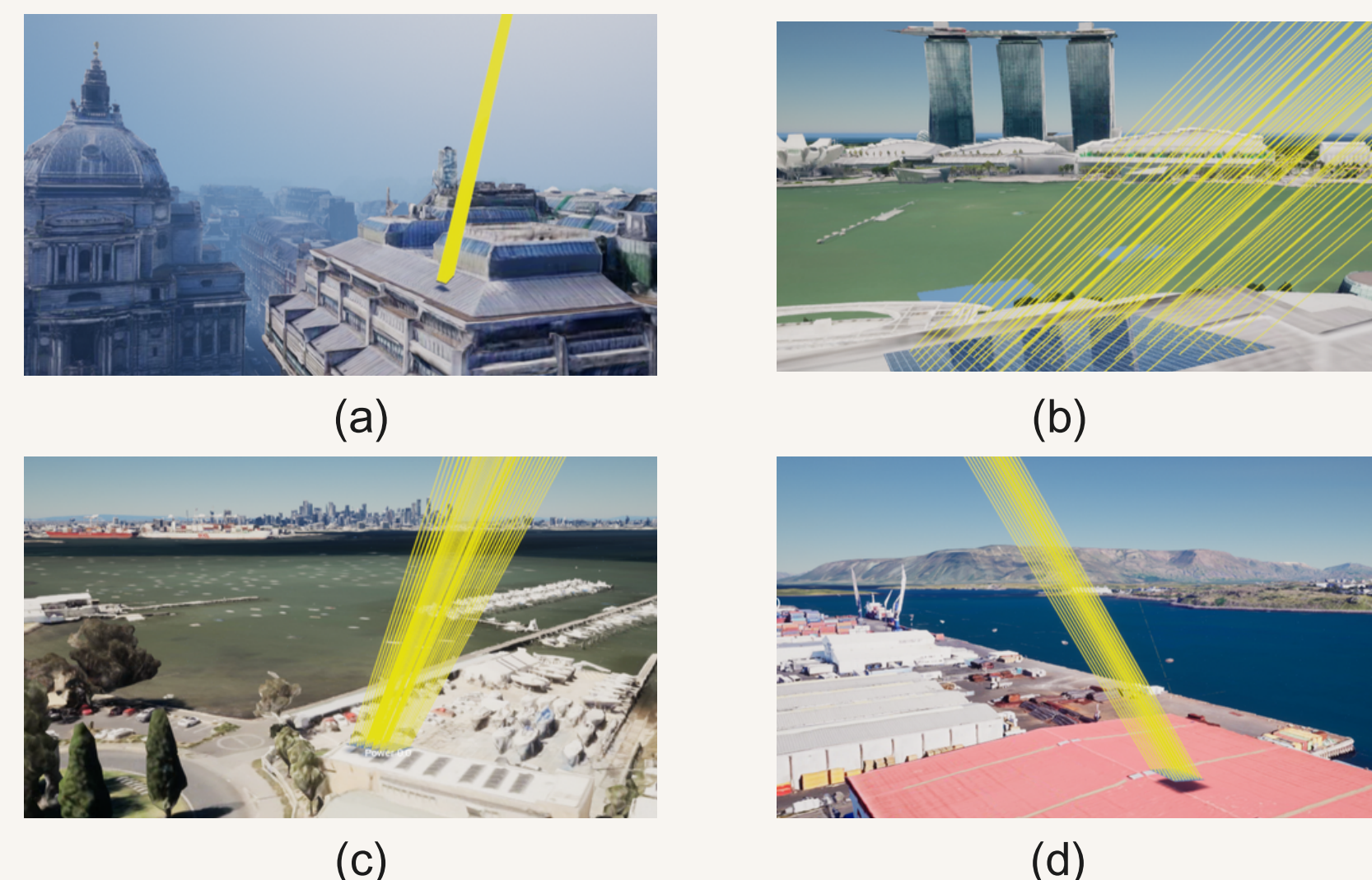


Figure 3: 120-cell solar module at (a) London, UK (b) Fullerton, Singapore (c) Melbourne, Australia (d) Reykjavik, Iceland - simulated for 2025-03-08 1400 hours

4. Conclusion

Digital Twins offer a powerful solution for renewable energy forecasting, addressing critical challenges in grid sustainability. By integrating real-time data, AI-driven modelling, these models enhance efficiency, reduce reliance on fossil fuels, and contribute to global decarbonisation efforts. Using Game Engines for Digital Twin simulations establishes an innovative approach for versatile renewable energy integrations, making it a scalable and a graspable solution for small and medium scale grids.

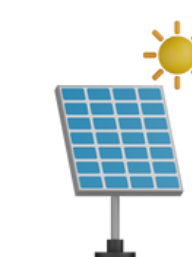
5. Future Directions

Future research could expand the Digital Twin framework to include wind, hydro, and biomass energy. Optimising AI and Machine Learning would improve prediction accuracy, enabling advanced multi-source renewable energy models. Additionally, integrating meta-learning approaches could assess and select the best-fit model based on season and geo-location. This approach would enhance grid management, paving the way for a smarter, more resilient energy future.

Our research highlights the potential of Digital Twin technology in accelerating the transition toward a low-carbon, sustainable energy grid 🌍⚡

References

Grieves, Michael. (2016). Origins of the Digital Twin Concept. 10.13140/RG.2.2.26367.61609.



For more information

Scan QR code
email: 2205279@buckingham.ac.uk

