P5 Presentation

An OGC 3D tiling technique based user-interactive platform for digital twins in a virtual reality environment

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Co-reader: Dr. Stefan van der Spek

Scheme of presentation

- Introduction and Motivation
- Research objectives/ questions
- Methodology
- Results
- Conclusions
- Limitations
- Future Scope
- Recommendations

Introduction: Smart Cities

Amsterdam Smart City Demo Days #16: Open for Applications

On June 14 and 21 the 16th edition of our Demo Days will take place. This will be the first Demo Days on location (will be announced soon) since COVID-19. Our themes for these upcoming Demo Days are:

Source: https://amsterdamsmartcity.com/

Rotterdam wins EU smart city subsidy

NEWS | GENERAL | NETHERLANDS | 12 JUL 2016 | BOOKMARK

Source: https://www.telecompaper.com/news/rotterdam-wins-eu-smart-city-subsidy--1152905

Singapore ranked top of smart city index for third year

News 02 Nov 2021 by SmartCitiesWorld news team

NEWS

Gothenburg joins smart cities bandwagon

Source: https://internetofbusiness.com/gothenburg-develops-smart-city-network/

Buenos Aires crowned smart city of the year

News 17 Nov 2021 by SmartCitiesWorld news team

Copenhagen tops digital cities ranking

14 June 2022
by Sarah Wray

Source: https://cities-today.com/copenhagen-tops-digital-cities-ranking/

Europe's push for smart cities

Over 2.8 billion cars are expected to be on our roads by 2036. Managing traffic is one way to tackle congestion. In the Netherlands, Amsterdam is testing new and old ways to get streets fit for the 21st century.

Source: https://www.dw.com/en/europes-push-for-smart-cities/av-60986391

Bhopal, Surat, Udaipur to be India's first smart cities

Of the 100 cities, the seven have taken a lead with most projects completed. Bhopal has completed 92% projects, Surat 82.44%, Udaipur 78%, Bhubaneswar 76%, Indore, Varanasi and Ahmedabad 70%.

04 May, 2022, 08.51 AM IST

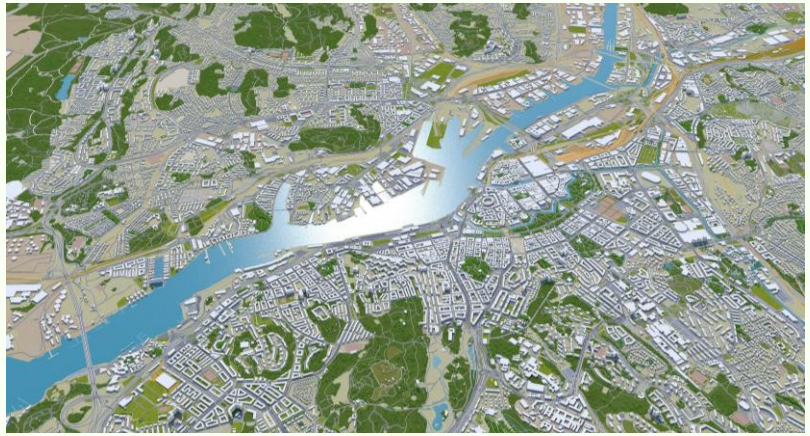
Source: https://economictimes.indiatimes.com/news/india/bhopal-surat-udaipur-to-be-in-list-of-7-smart-cities/articleshow/91295388.cms

Introduction: Urban Digital Twins

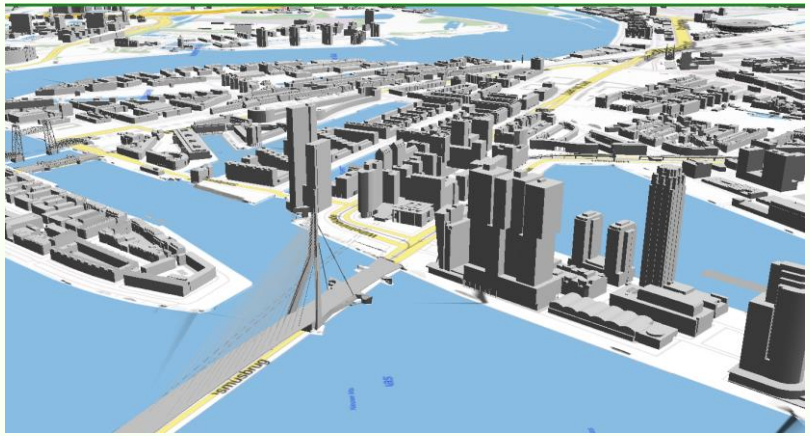
3D BAG

3D Amsterdam

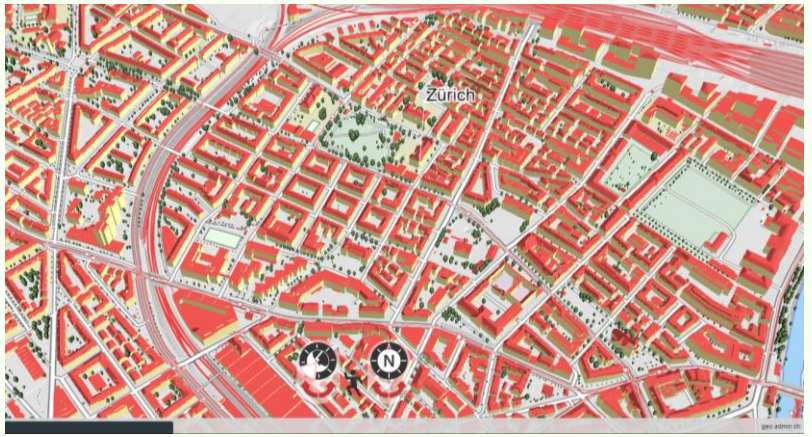
Virtual Singapore



3D Gothenburg



3D Rotterdam



Swiss Topo

Introduction: 3D Tiles

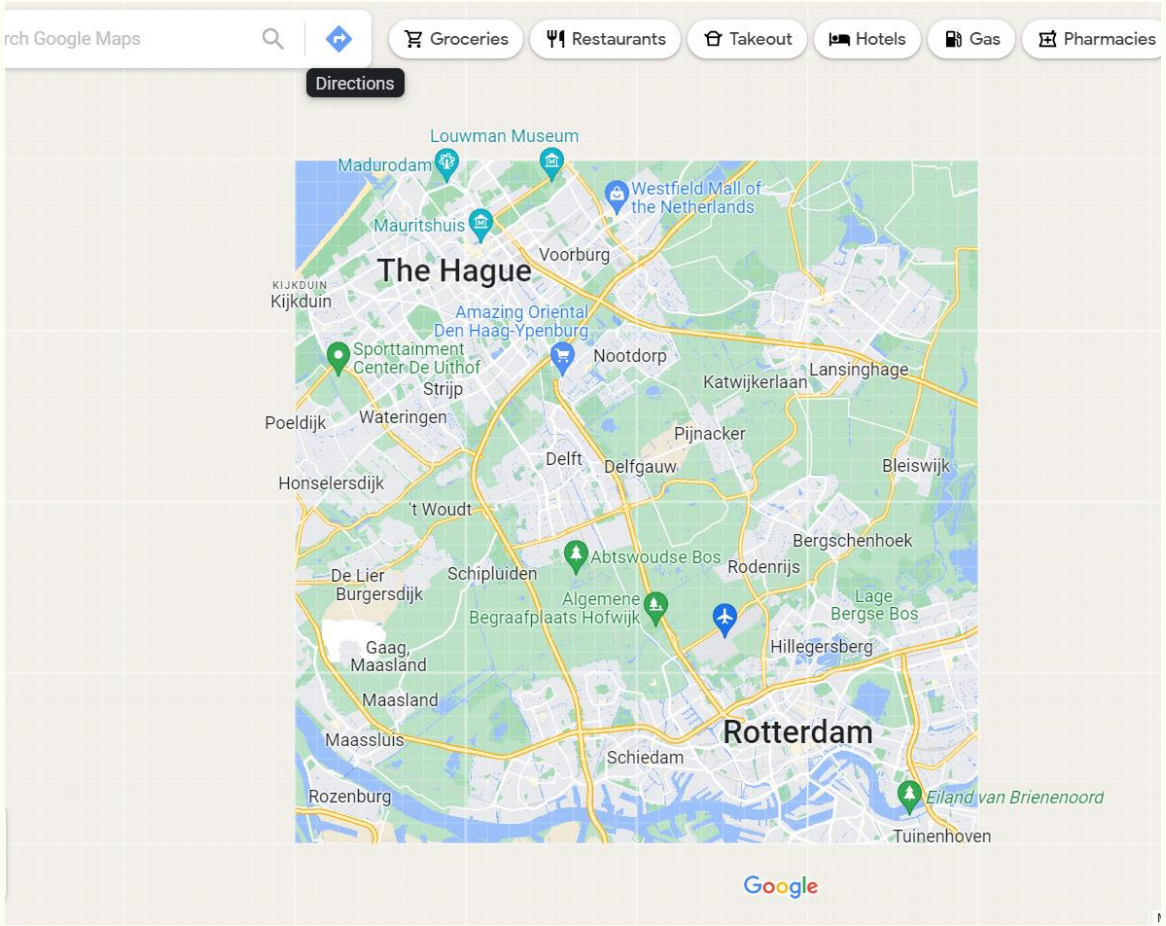
- Large datasets
  - 200MB datasets for a small city
- OGC 3D tiling
  - Specification developed for "sharing, visualizing, fusing, interacting with, and analysing massive heterogeneous 3D geospatial content across desktop, web, and mobile applications"
  - Efficient loading of 3D data
  - Lesser client side load

City	3D dataset size (MB)
Zurich (Buildings)	3030
New York (Single tile buildings)	509
Montreal (Single tile)	56
Vienna	37
Den Haag (Single tile)	23
Rotterdam (Single neighbourhood)	16

Source: CesiumGS

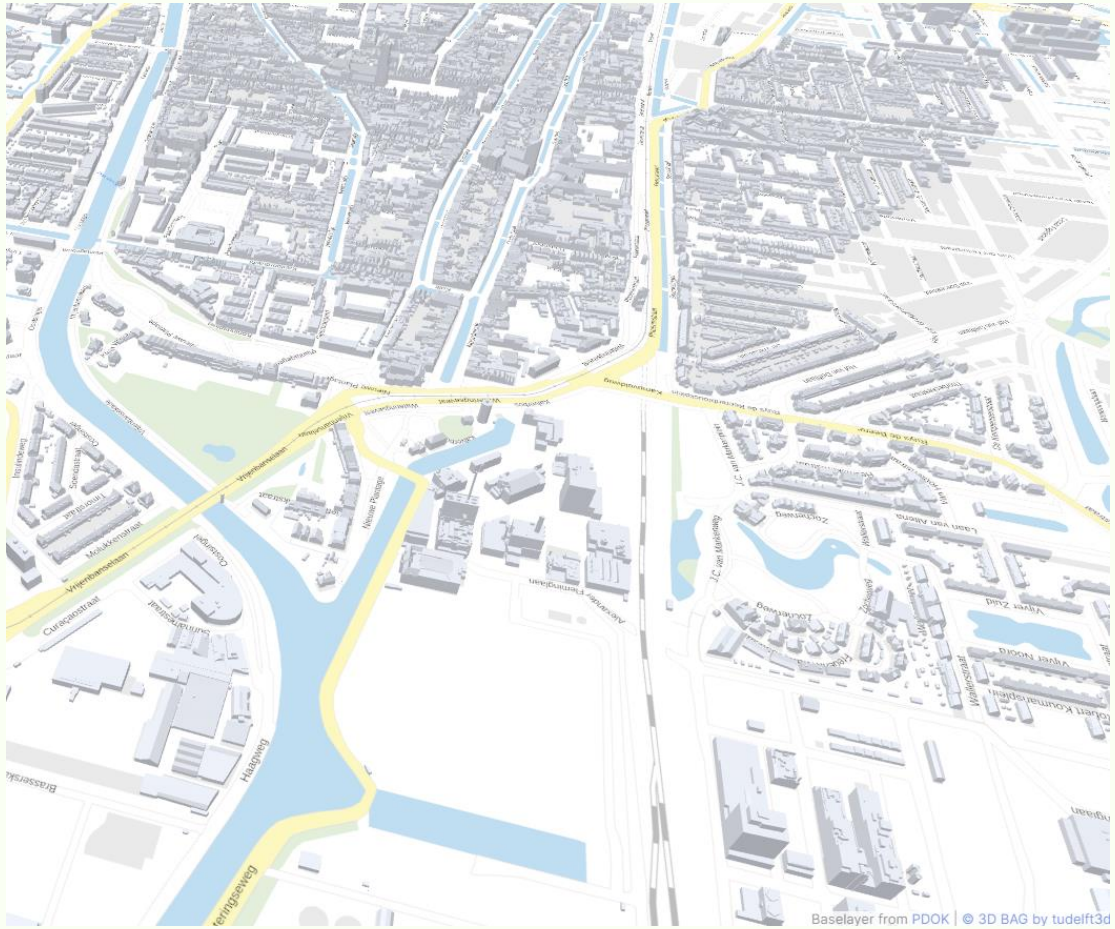
Introduction: What are 3D tiles?

Partially loaded 2D tiled map



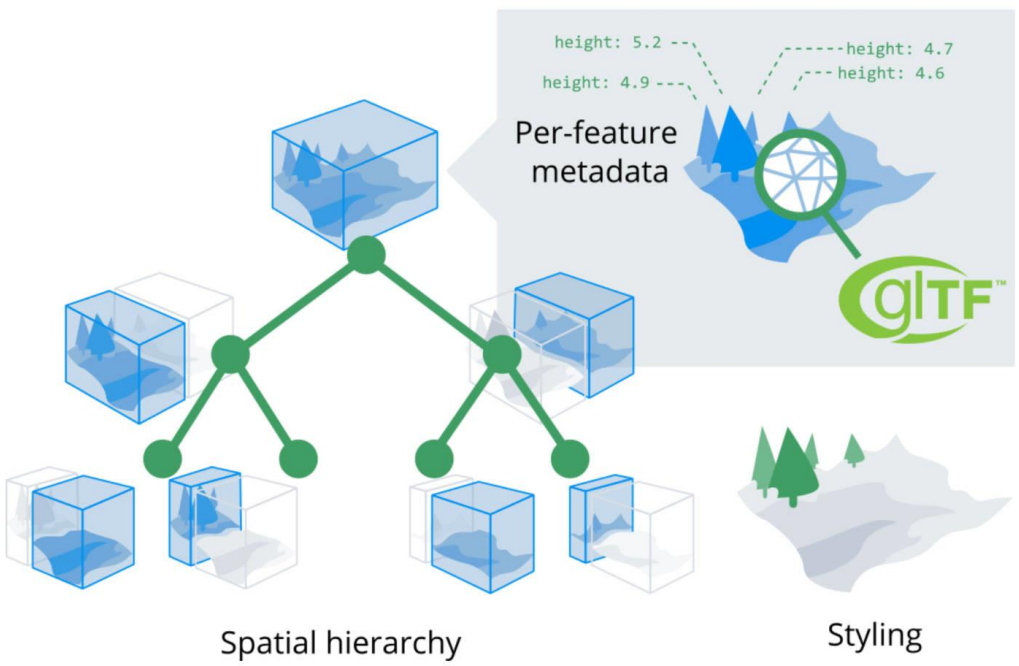
Source:Google Maps

Partially loaded 3D tiled map



Source: 3dbag.nl

Introduction: 3D Tiles Hierarchical LoD and Refinement



Source: Khronos Group

Source: CesiumGS

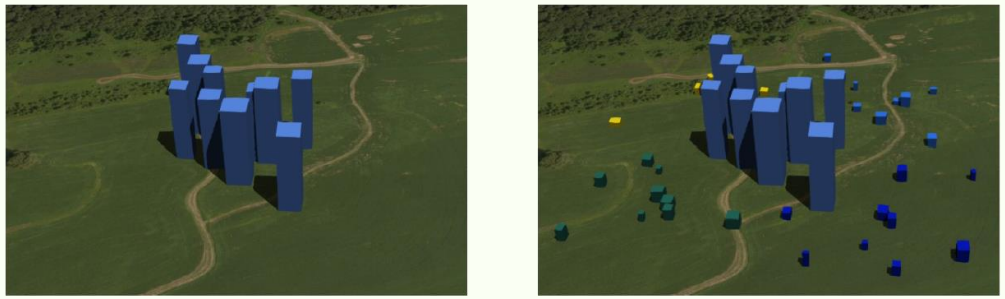
Refinement Strategy

Replacement refinement

(a) Parent (b) Refined

Source: CesiumGS

Additive refinement



(a) Parent (b) Refined

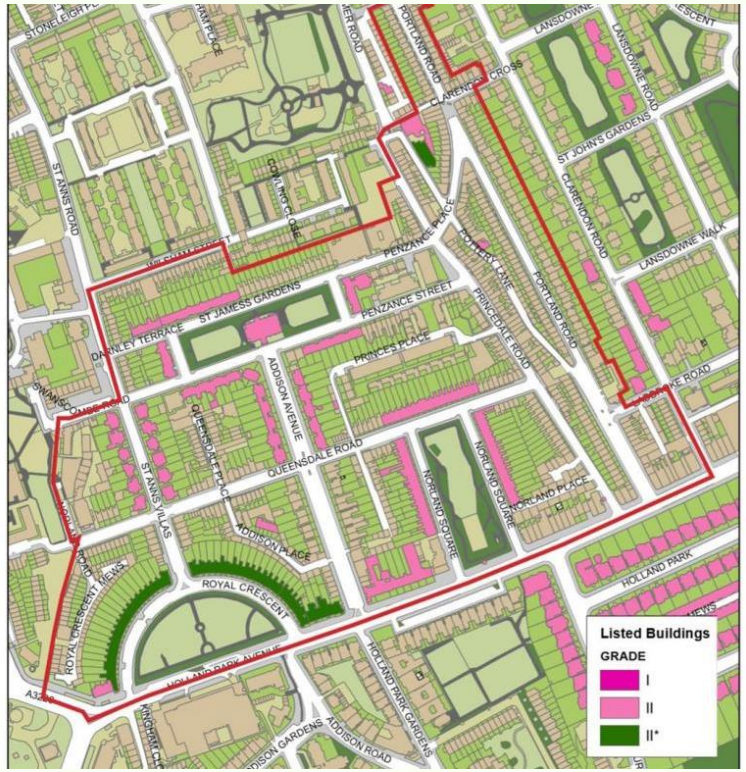
Source: CesiumGS

Introduction: 3D tiling formats

Format	Extension	Usage
Batched 3D models	.b3dm	Heterogeneous 3D models. E.g. textured terrain and surfaces, 3D building exteriors and interiors, massive models.
Instanced 3D models	.i3dm	3D model instances. E.g. trees, windmills, bolts.
Point Cloud tiles	.pnts	Massive number of points.
Composite tiles	.cmpt	Concatenate tiles of different formats into one tile.

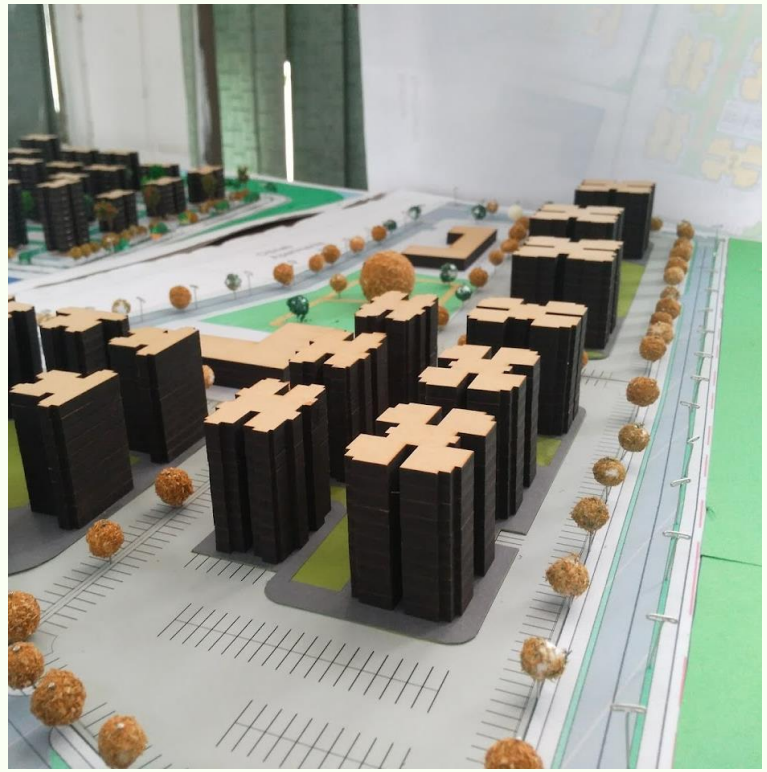
Introduction: 2D planning -> 3D planning

2D Neighbourhood plan



Source: https://www.rbkc.gov.uk/

Scaled 3D maquettes



Objective/Research questions

- Focus: development of a user interactive platform for neighbourhood design with possibility to visualise and use the platform using virtual reality (VR).

- Developed in a gaming engine (Unreal Engine)

  - Game physics for rendering

  - Allows a more immersive experience for the end-user.

Objective/Research questions

- Primary Research Question:
  - **To what extent can we make a combination of existing 3D city datasets with a user interactive neighbourhood designing platform in a virtual reality environment?**

- Sub Questions
  - Can the 3D tiling technique be utilized for the use case of urban neighbourhood development?
  - In the use case of urban neighbourhood design, how can dynamic user selected designs be effectively visualized?
  - How can user-designed neighbourhoods be dynamically disseminated in the form of 3D tiling to incorporate it with the rest of the contextual 3D tiles?

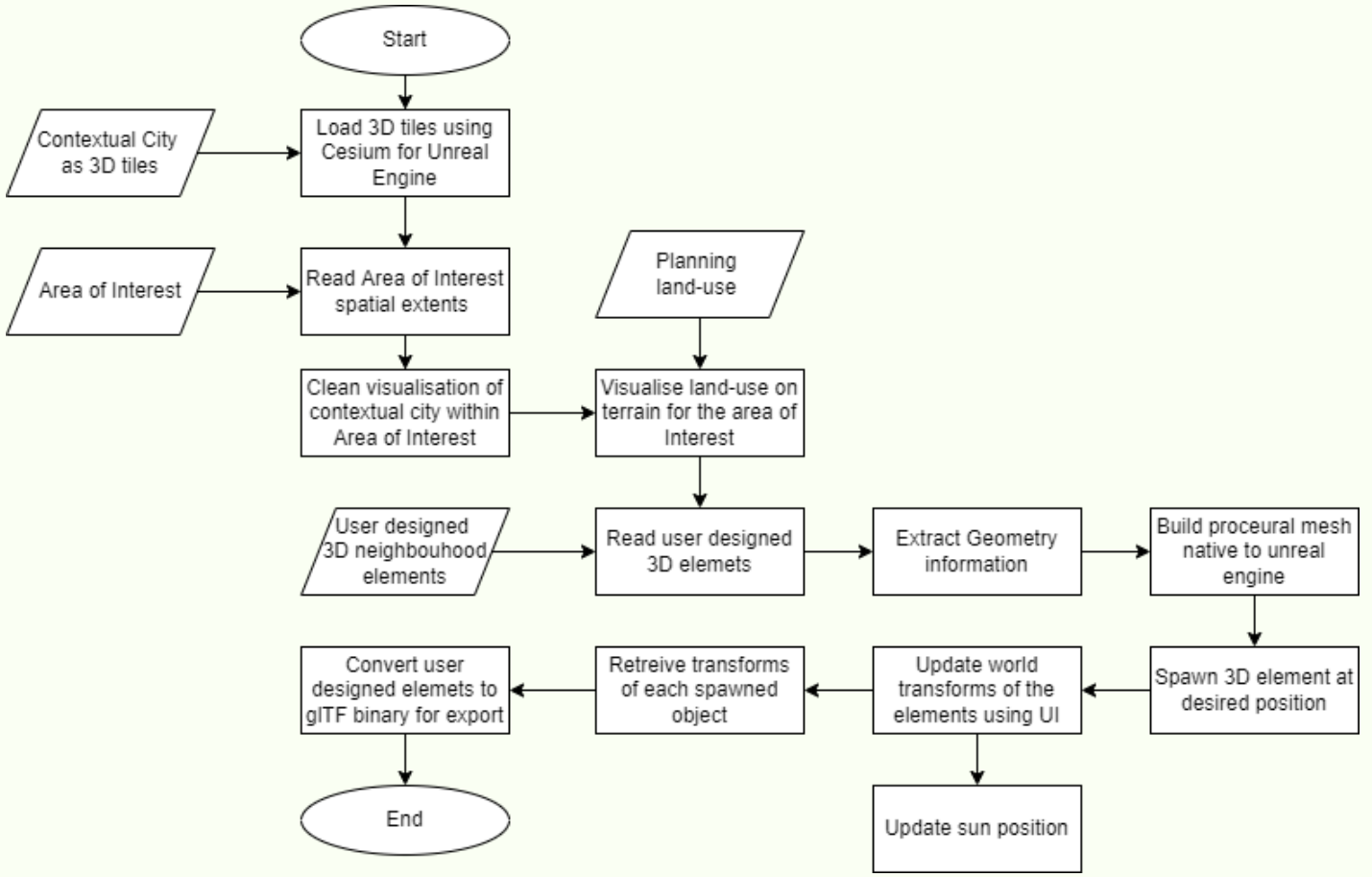
Methodology

3D tiles in Urban Neighbourhood Design

- Load city context in 3D
- Load and empty out Area of Interest
- Load Land Use Plan

Effective visualisation & Dynamic dissemination of 3D tiles with user design

- VR visualization
- Composing user design with contextual 3D tiles
- Integrate user design with 3D tiles



Datasets, Software & Hardware used

		Reason for usage
Dataset	3D City model of the Netherlands	To load it in as the context model in 3D tiles format, obtained from 3D BAG
	Proposed land use plan	To display in the background while designing neighbourhood, obtained as WMS layer NL.IMRO.0503.SV0001-2001 from Ruimtelijke Plannen
	3D objects	To be used for creating the user-made neighbourhood
Tools and Software	Unreal Engine	As the platform where the application is developed
	Geodan pg2b3dm tool	For conversion of PostgreSQL database to b3dm batched model
	GeoPipe gltf2glb and gltf2i3dm tool	For conversion of glb object with json instancing to i3dm tileset
	QGIS	To visualize intermediary results from data sources
	Safe FME	For conversion of 3D objects to batched model in required reference system
	VS Code	For reading through the tileset.json file formed and programming in C++
	Steam VR	To interact with the VR controllers inside the application
	Cesium ion	To create a web-hosted batched model
	Git(Hub)	To maintain a version controlled environment for developing the platform as well as the report
Hardware	HTC Vive VR Headset and Controllers	To utilize the VR capability of the developed platform and for testing in VR

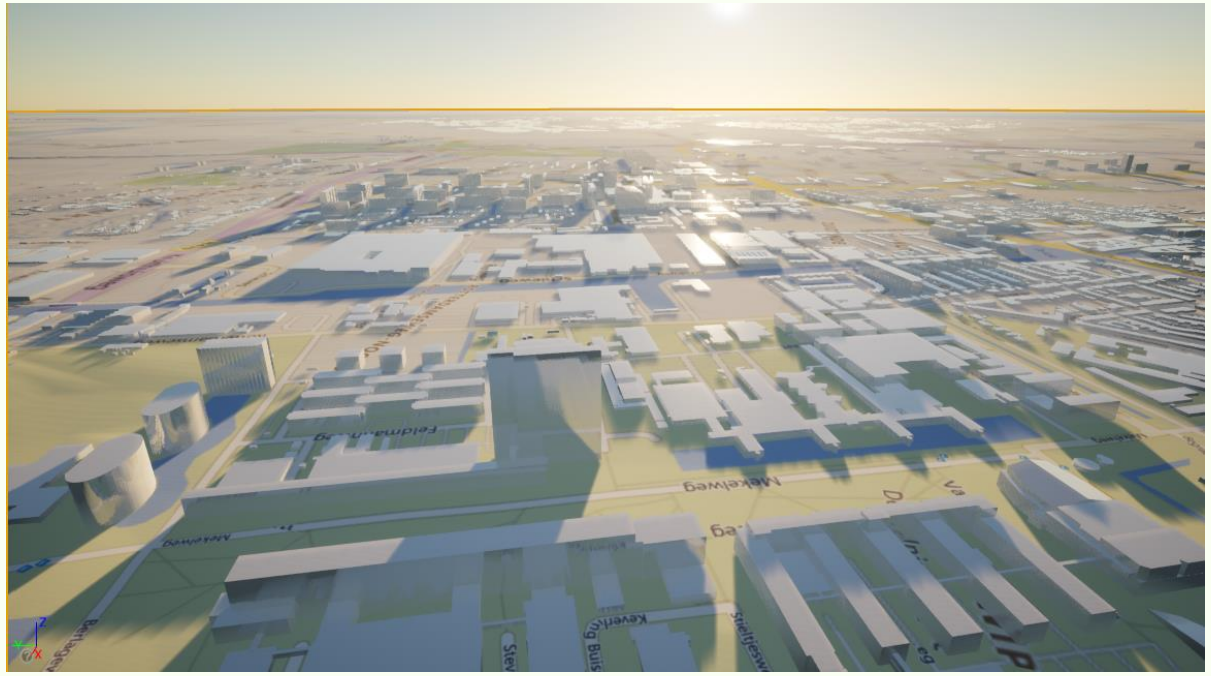
Results

- Loading Contextual city model
- Ingesting Area of Interest (AoI)
  - Removing objects inside AoI
- User-made neighbourhood design
  - Placing user built objects inside AoI
  - Updating position and rotation of User objects
- Updating sun position for shadow visualisation
- VR based visualisation

Results: Loading 3D model

LoD 2.2 dataset from 3D BAG

LoD 1 dataset from Open Street Maps

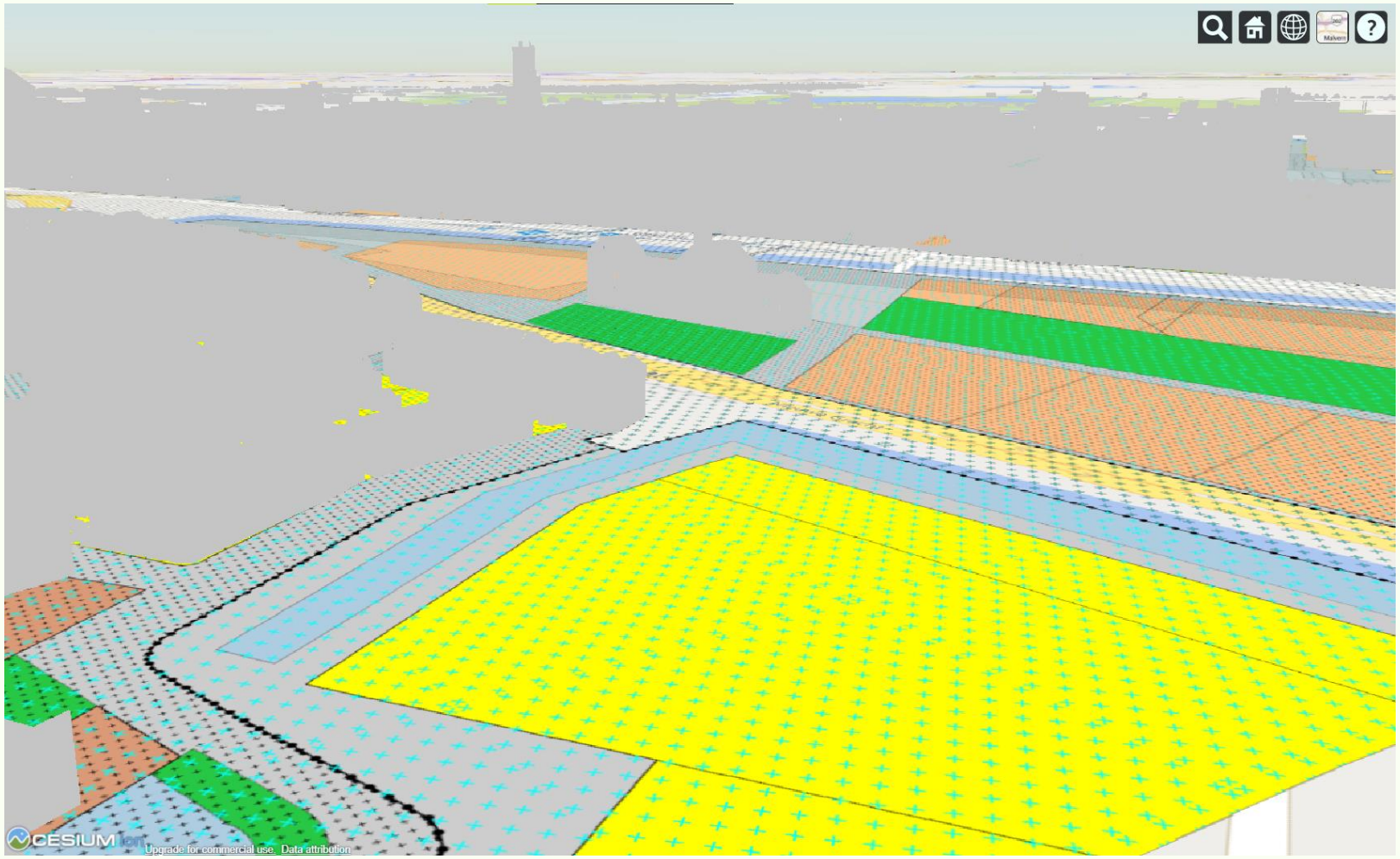


Results: Ingesting AoI and removal of objects

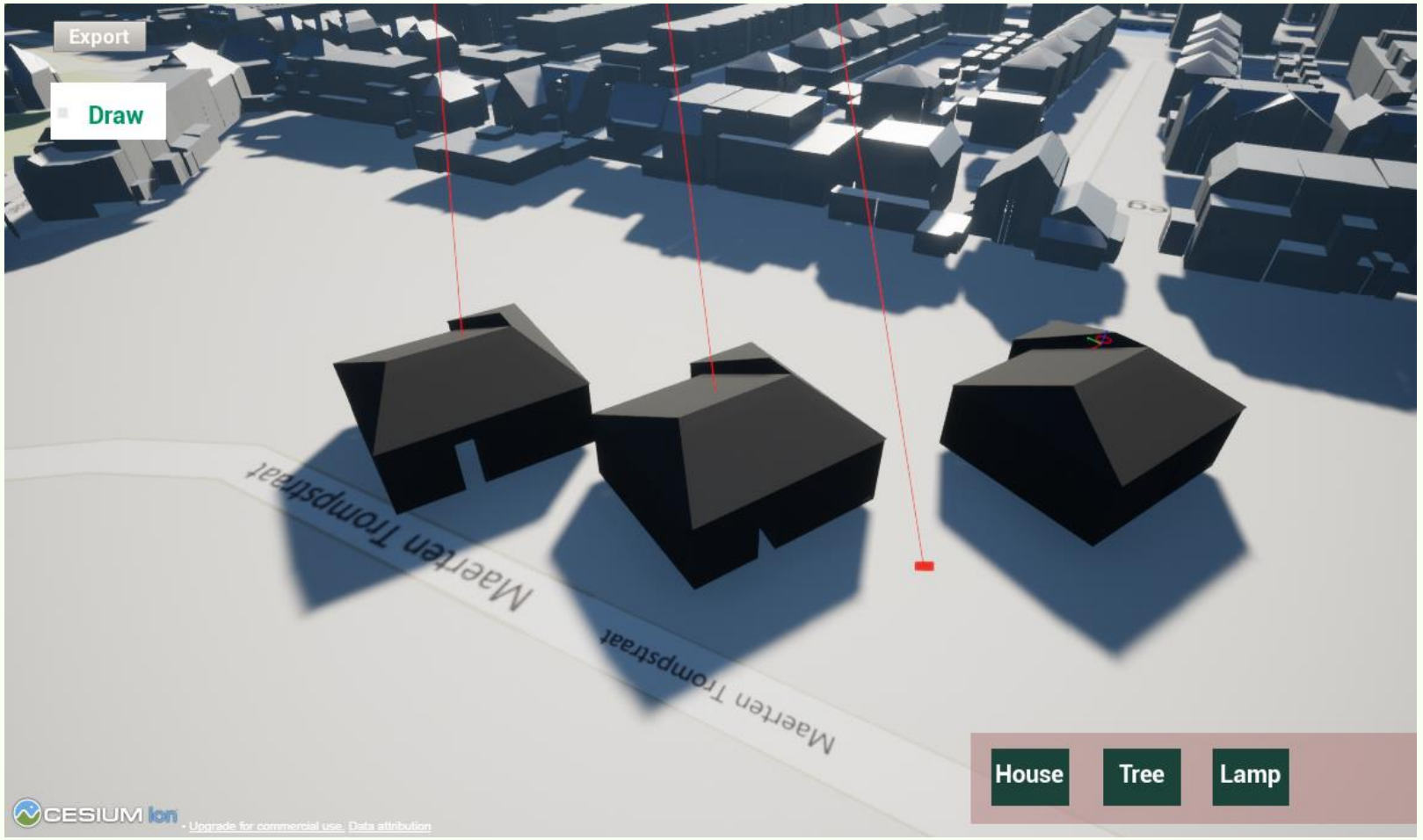
Before cleaning of 3D dataset within AoI

After cleaning of 3D dataset within AoI

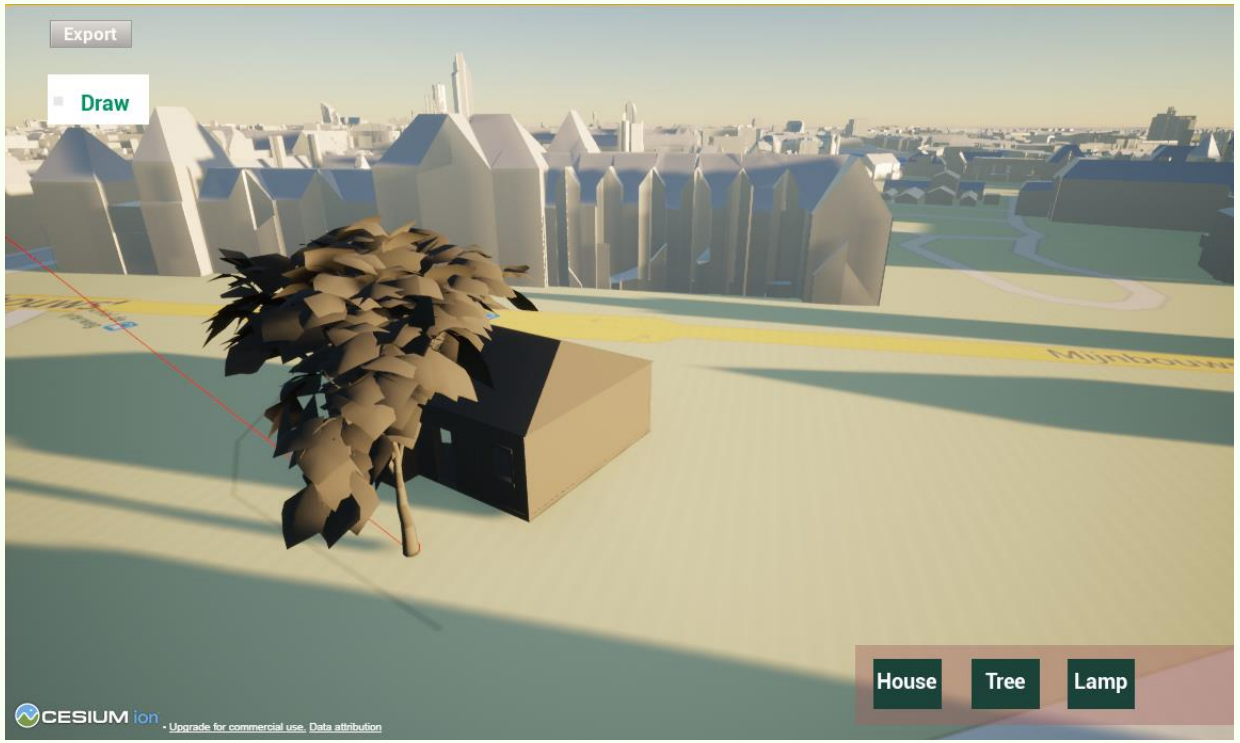
Results: Land use as background

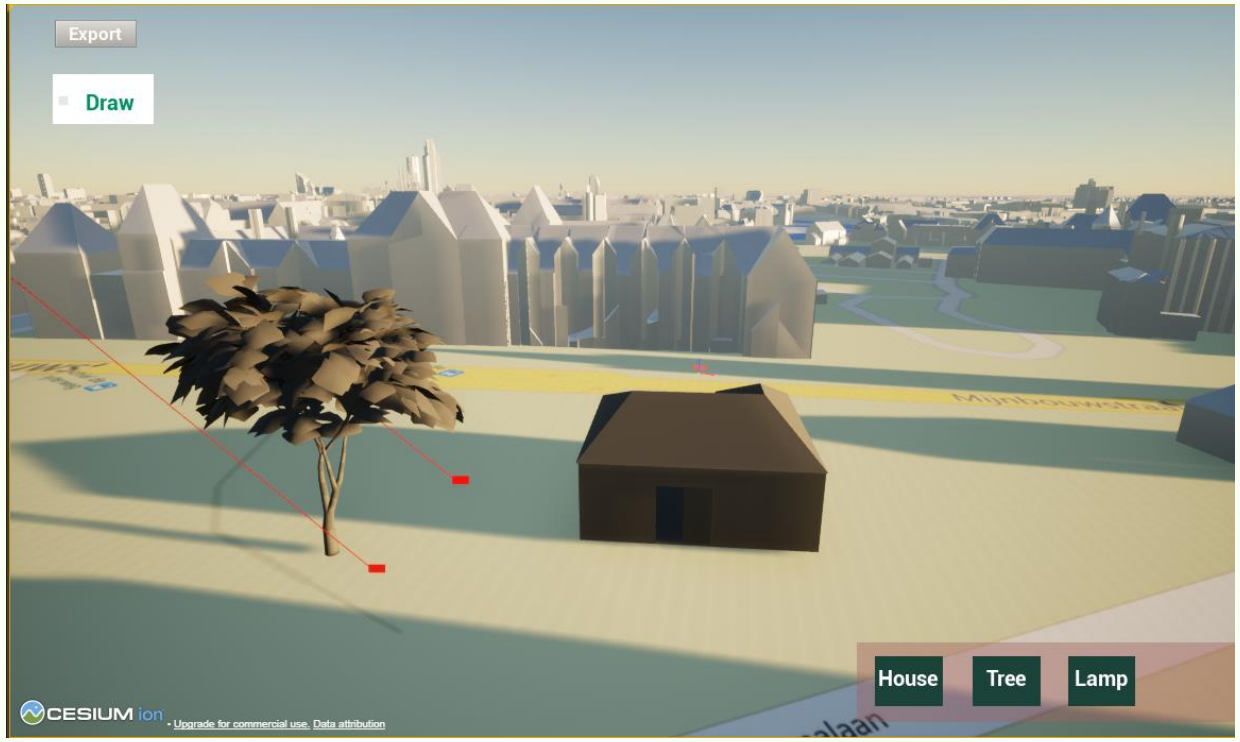


Results: Placing User-built objects

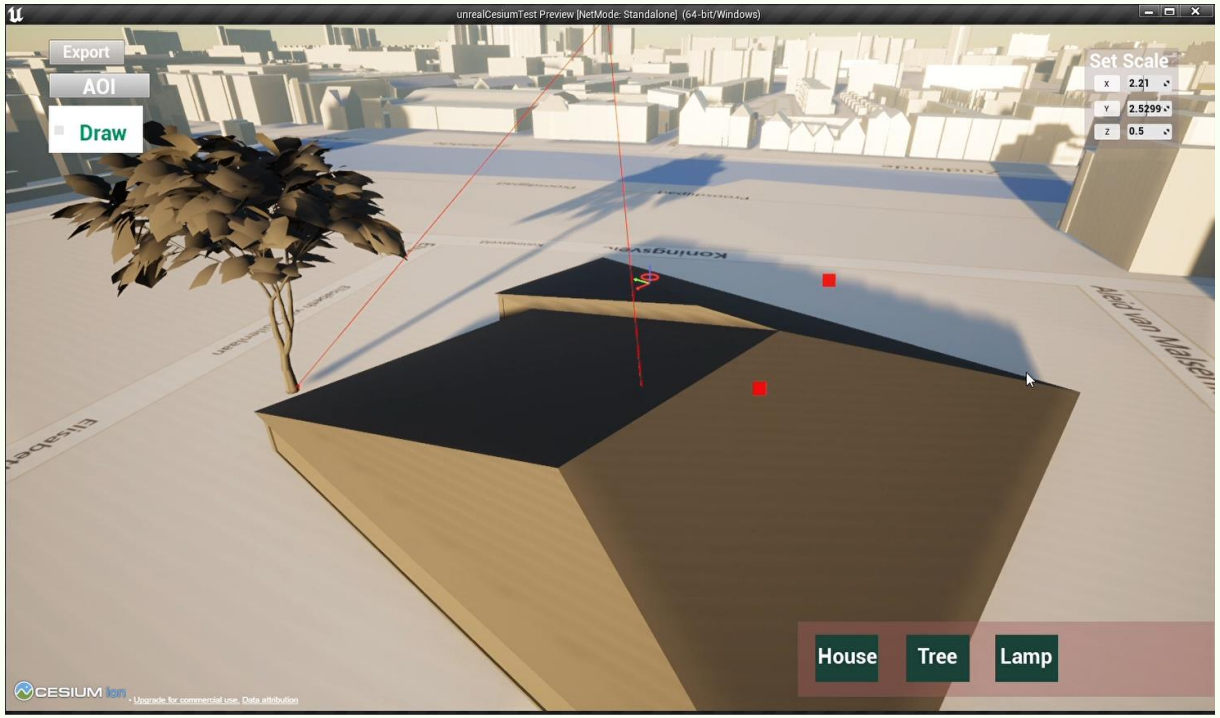


Results: Changing transform of use-input objects

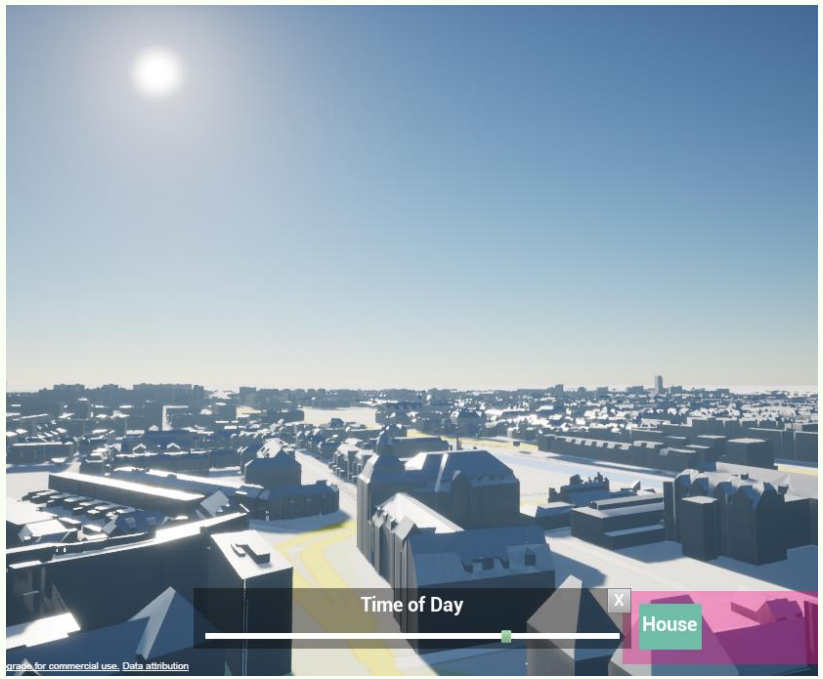


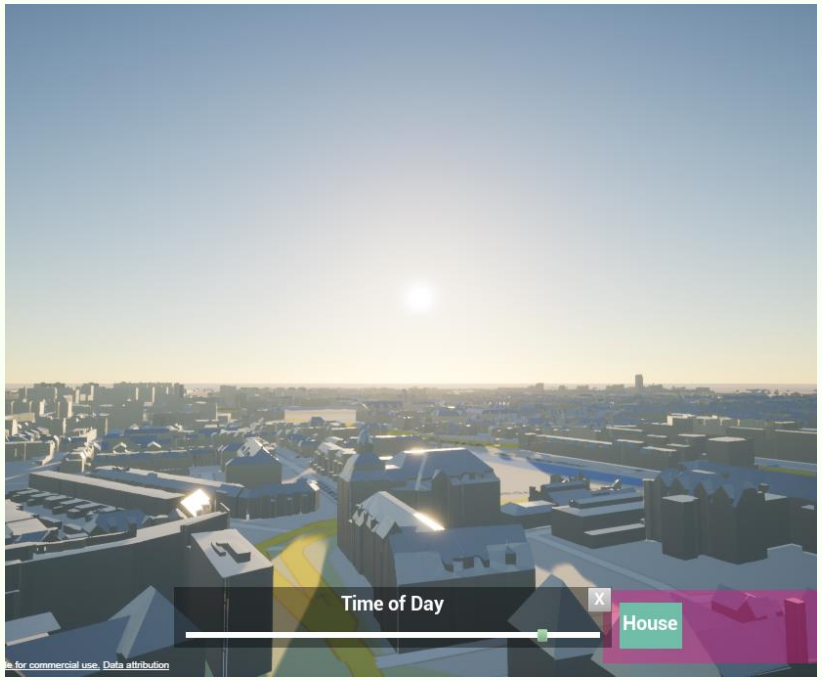


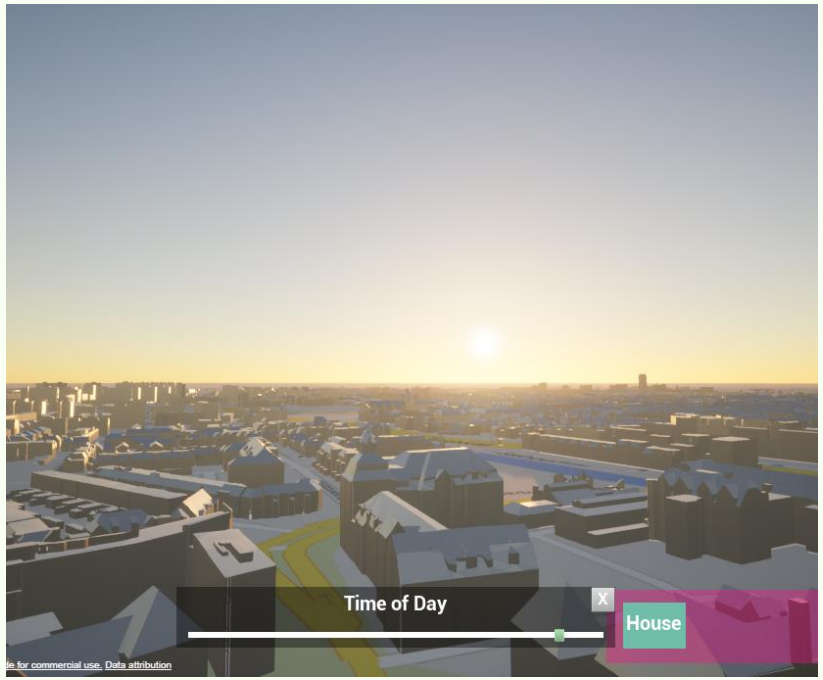
Results: Changing scale of use-input objects



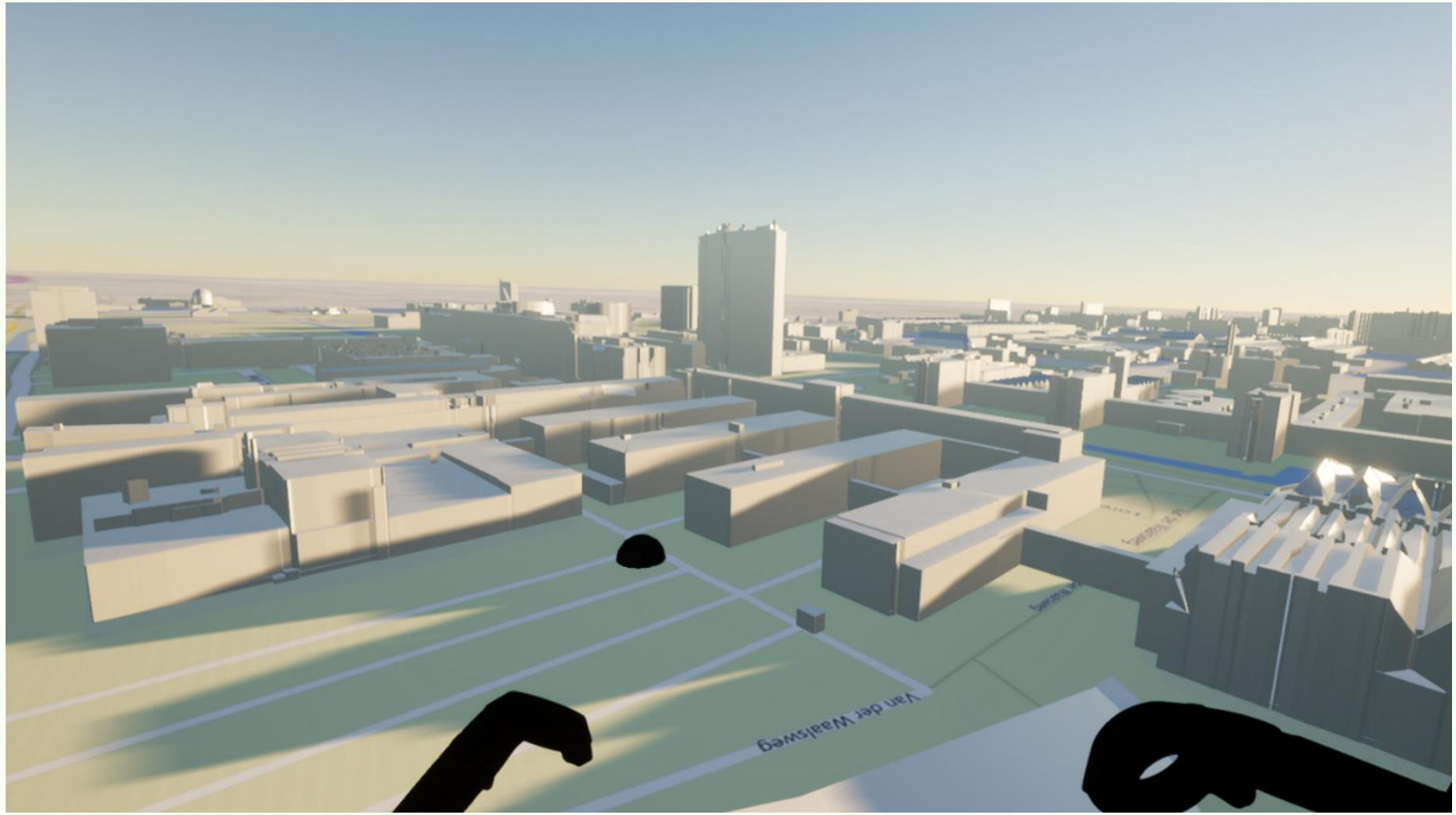
Results: Updating Shadow to time of day



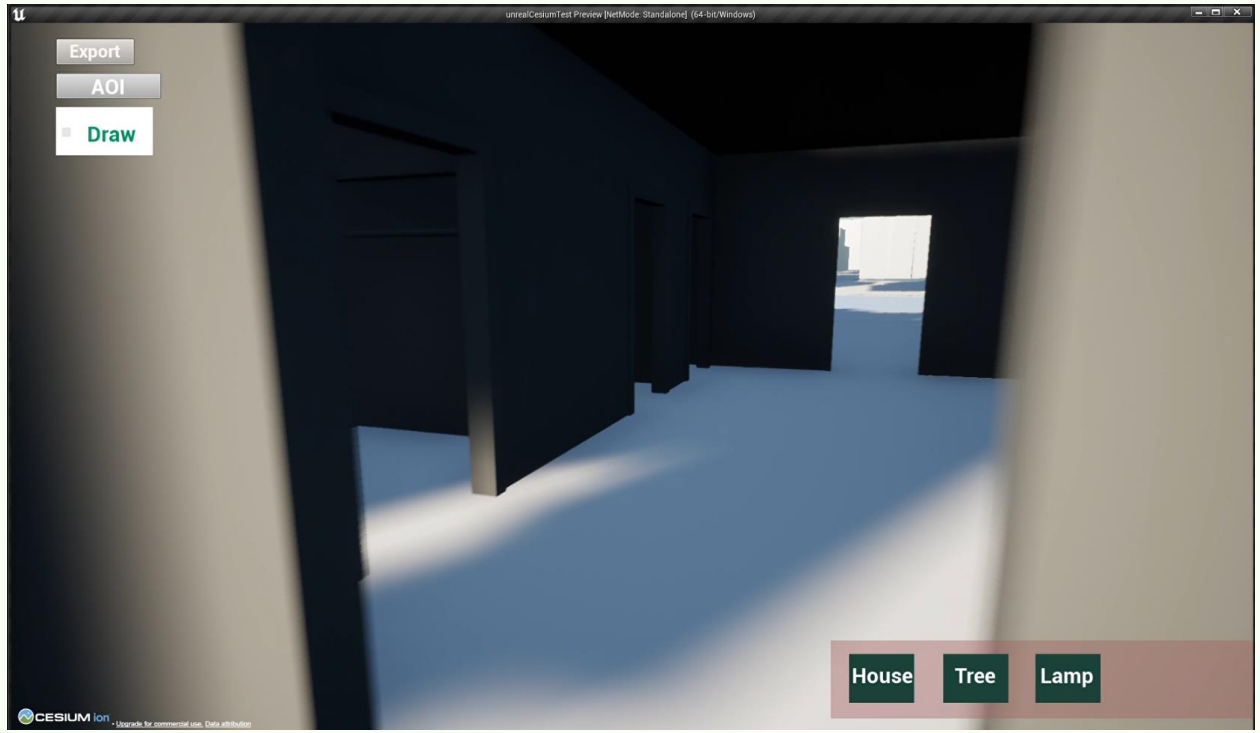


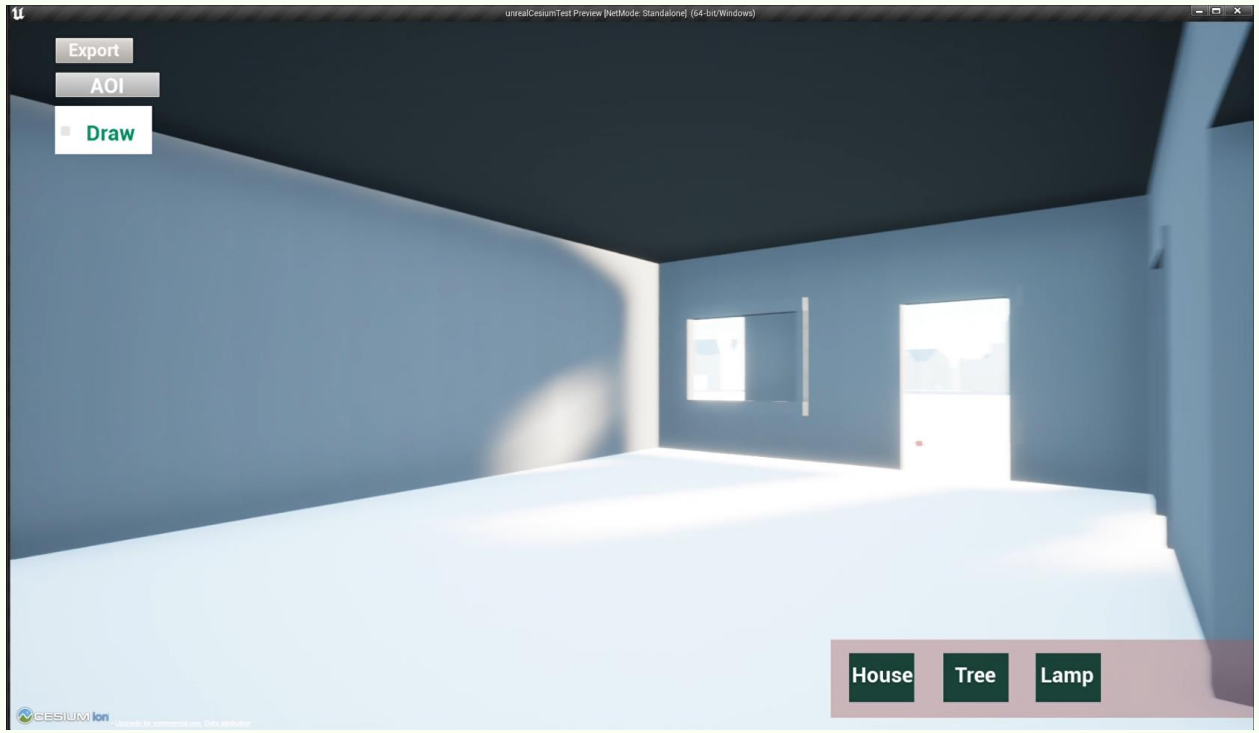


Results: VR visualisation



Results: LoD4 enabled





Conclusions

Can the 3D tiling technique be utilized for the use case of urban neighbourhood development?

- Yes, 3D tiling can be used in case of urban neighbourhood development

- Advantages of 3D tiles:
  - Lesser client load
  - Standardized 3D data exchange format

Conclusions

In the use case of urban neighbourhood design, how can dynamic user selected designs be effectively visualized?

- User 3D object visualised natively overlaid on top of the contextual 3D city

- Exported instanced model can be natively viewed in CesiumJS, Mapbox or threeJS

Conclusions

How can user-designed neighbourhoods be dynamically disseminated in the form of 3D tiling to incorporate it with the rest of the contextual 3D tiles?

- Instanced model or composite model for design exchange
- Composite tiling to integrate with contextual city model
- Extensions of 3D tiles

Limitations

- Instanced and composite tiling format
  - Not natively supported at present
- Extensions support
  - No Cesium for unreal native support
- Coordinate reference system
  - Tiling needed in EPSG:4978

Future Scope

- Real time datasets visualisation
- Urban simulations
- Centralised 3D data dissemination architecture
- Improve replacement strategy

Recommendations

- Optimization of tiling technique
- Automated design of neighbourhoods
- Effectiveness of VR in urban design

Thank You!

We are now open for questions and discussion.

github.com/pratyush1611/3dTilesThesis