Creating an interactive 3D dashboard to track campus resource consumption

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Project Introduction

Lancaster University is attempting to reduce carbon emissions by 83% from its 2005 baseline by 2050. Resource consumption data is collected from over **30,000** sensors on campus every 10 minutes but is not further analysed to track carbon reduction efforts and identify inefficiencies.

This project serves to initially process the high-volume data into a clean, standardized format that can be loaded for visualisation and analysis. To display this cleaned data, a dashboard is created which visualises consumption using novel 3D temporal mapping to enhance understanding of spatial-temporal consumption trends.

Lancaster University carbon emission targets from 2005 to 2050

	Baseline Emissions		Target Year			
		2005	2012	2017	2020	2050
Higher Education Sector target for carbon emission	(% reduction)	n/a	12	29	43	83
Lancaster University carbon emission targets	(% reduction)	n/a	34.9	35.6	43	83
	(tCO_2e)	26,043	16,953	16,771	14,844	4,427
Lancaster University real carbon emissions	(% reduction)	-	12	29	-	-
	(tCO_2e)	26,043	22,658	18,163	-	-

Data Processing

- Data is standardized by identifying the different consumption sensor types and applying separate processing to each to create a uniform dataset.
- Errors are automatically detected and removed using a custom-created rule. Small sets of erroneous data are replaced using interpolation.
- OpenStreetMap data is linked to internal university datasets using a string metric called Levenshtein distance
- Where internal university datasets lack internal area data for buildings, it is estimated using building footprint and number of floors.

Novel 3D Temporal Mapping

- Currently, no map libraries allow the creation of temporal 3D maps. Some commercial solutions exist but are not suited for very large datasets such as the university's consumption data. Therefore, two ways to create a 3D temporal map are explored, both using innovative methods. They are benchmarked on how long they take to colour a map by building consumption and evaluated based on time taken, performance and security.

Performance of two different temporal mapping methods

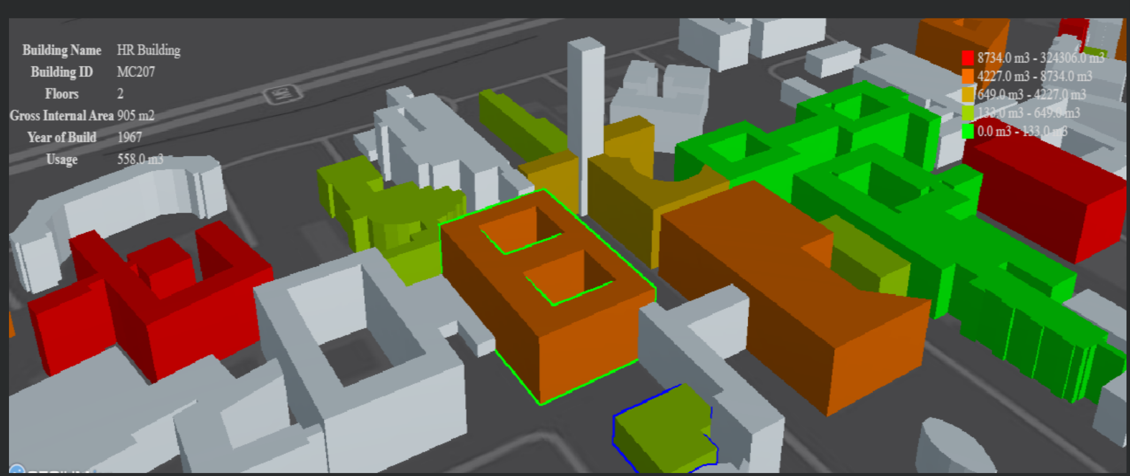
	CZML Approach	Integrated Approach
Avg. time taken to colour map (s)	7.5	3.7
Avg. frame rate during colouring	7.07	53.5
Peak memory consumption (MB)	93.4	58.4

- The best performing solution is achieved by integrating CesiumJS 3D mapping into the Dash Python library environment to create a powerful backend processing capacity with a browser based client-side visualisation. This solution offers improved security, load times and performance.

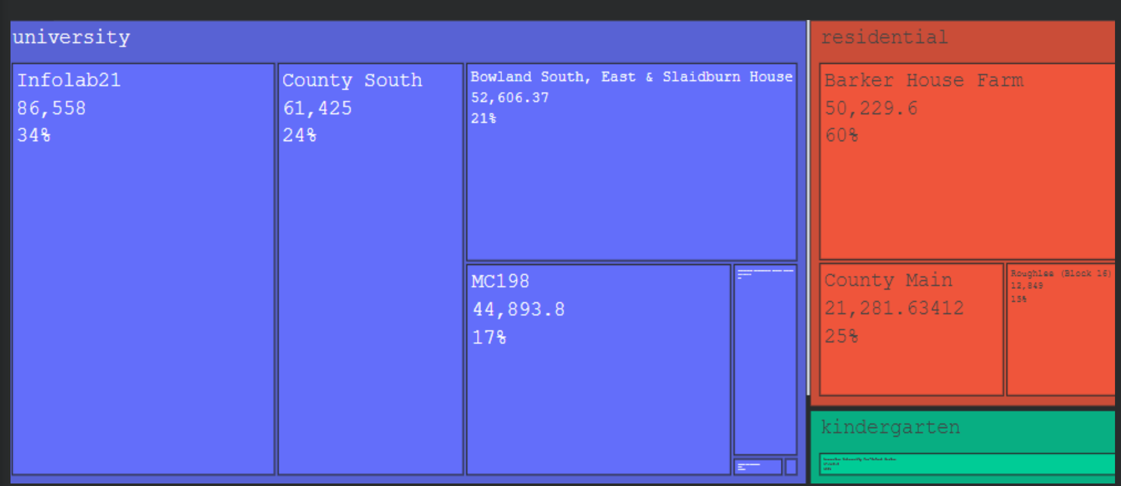
Dashboard Features

(*The user first selects the type of consumption they wish to visualise (heat, water, gas, electricity) and for which time period*)

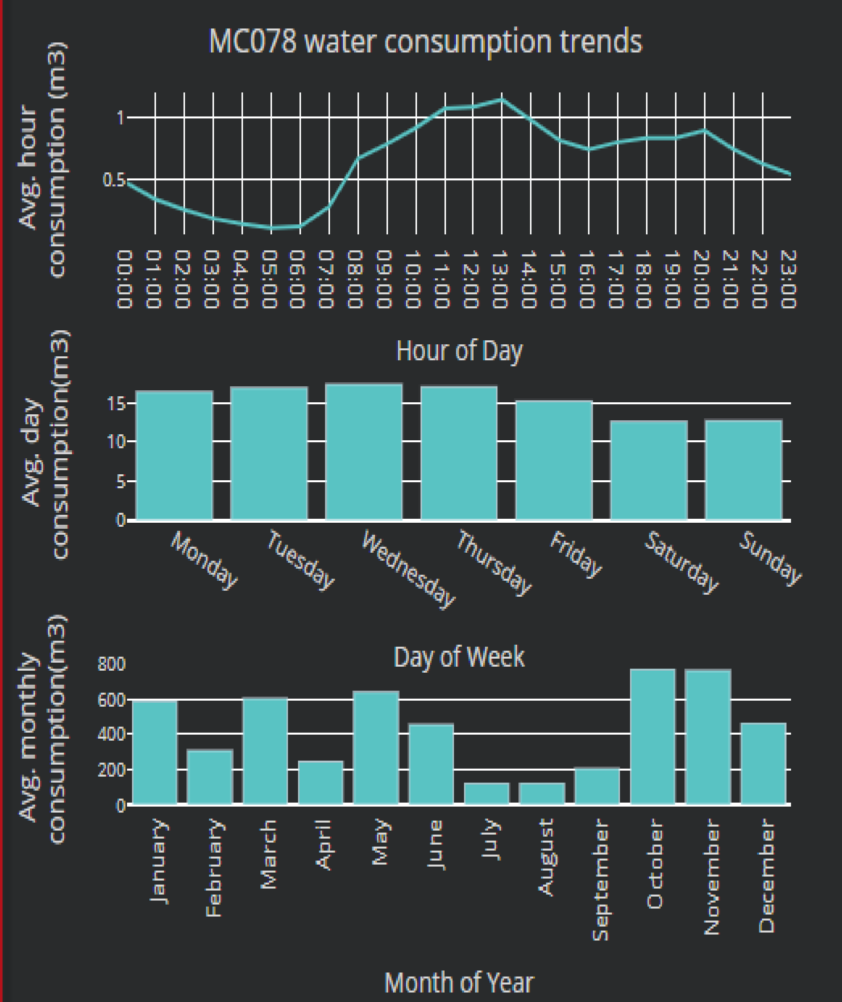
Buildings are coloured on the 3D map based on total consumption or occupancy in time period selected



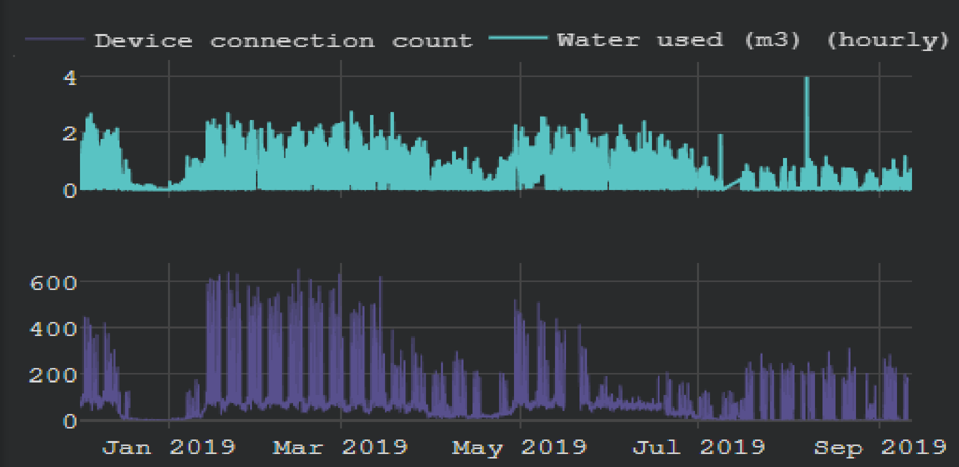
Individual building shares of total consumption are shown using a treemap



Seasonal trends are calculated by the server to display average consumption by hour, day of week, month for the building selected on the map



Historical consumption graphs with 1 hour resolution plotted on building selection



Map can be filtered by internal area and year of build

Filtering to only display buildings of area 5000m^2 or higher

Conclusion

- The bulk consumption and occupancy data has been successfully processed into a standardized form using a custom-created Python program
- Novel 3D temporal mapping techniques have been created, both of which may be of use in a broad range of applications such as traffic monitoring or work campus consumption tracking
- A dashboard utilizing this novel mapping technique has been created, offering a multitude of information to users both building-specific and about campus as a whole
- The dashboard is now ready to deploy for use at the university in order to help:
  - Track overall progress in reducing consumption to meet carbon efficiency targets, particularly for stakeholders
  - Monitor individual buildings as well as identify inefficient buildings and faulty sensors, useful for facilities staff and managers

Lancaster University, "Carbon Management Plan," 2018
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