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Towards Context & Climate Sensitive Urban Design

An integrated simulation and parametric design approach

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DESIGN PLATFORM & FRAMEWORK

Supporting urban bioclimatic design

To implement the concept of integrated design, an urban modelling, simulation and design platform was developed. It embeds a design framework built upon the strengths of parametric modelling and existing building performance simulation tools.



Rhino's viewport integrated user interface and urban 3D model



The **centralisation** of the synthesis, analysis, evaluation and optimisation **activities** in a single interface helps to support the integrated design concept. Data exchange and treatment allow **informing** both the simulation tools and the design process in terms of context and climate consideration.

Optimisation

PARAMETRIC STUDY

Impact of modelling simplification on solar potential

2000

1800

1600

1400

1200

1000

800

600

400

200

1273

1091

1455

1273

1091

1818

8.2%

The parametric generation of the urban environment and it constitutive elements allows running similar simulation with various scenarios. Here the most detailed 3D model simplified gradually to assess the impact of each modelling scenario on the solar potential of more detailed ones.



Radiance parameters	ab=2, ad=1000, as=16, ar=98, grid size=1m
DS Detailed scenario	Ovoid trees, detailed ground materials distribution (asphalt/grass), extended surrounding, sampled topography
S1 Spherical trees	DS with simple trees instead of ovoid trees
S2 No trees	S1 with trees removed
S3 All asphalt	S2 with all asphalt ground instead of the asphalt/grass distribution
S4 Lambertian ground	S3 with 20% reflective lambertian ground instead of all asphalt
S5 First surrounding	S4 with extended surrounding removed, only first radius of surrounding buildings kept
S6 No surrounding	S5 with no surrounding buildings
\$7 Unsampled terrain	S6 with SRTM (30m precision) terrain instead of 3m sampled terrain
S8 Flat terrain	S7 with flat terrain instead of SRTM

Data Min -143

Data Min -228

Data Max 96

-400

-608

-840

-1072

1303

0.1%

0.0%

0.0%

-1077

-1430



Parameters

Synthesis

O2 Design vector Constraints & Parameters C1 Data storage C2 Constraints C3 Constraints violation

🖊 Evaluation

Synthesis

S1 Interpreter S2 Topography

S3 Open space S4 Existing buildings

S5 New buildings

S6 Data structure

Analysis

A2 Climate

A4 Building performance

Evaluation

E1 Flow control

E2 Utility functions

E3 Weight factors

Optimisation

O1 PSO algorithm

E4 Objective function

A1 Morphology

A3 Microclimate

Design framework The context and climate sensitive urban design framework

Platform levels of transparency User interface, directed acyclic graph and textual code

SYNTHESIS

S3

Parametric generation of the urban environment



Topography A sampling script allows matching measured elevation (3m grid) of the studied area with larger satellite elevation of the surrounding terrain (SRTM 30m grid)



Open spaces & natural elements are modelled based on measurements (or GIS data) of their boundaries. Trees are modelled as ovoids based on surveyed characteristics (height, width, density)





The parametric modelling capacities of the software pair Rhinoceros-Grasshopper are used to generate a synthesis model of interrelated urban elements. Topography, buildings, open spaces and natural elements are connected with each other in an algorithmic relation.



Vauban neighbourhood, case study located in St-Denis, La Réunion

DS Detailed scenario solar potential Basements of buildings are not studied and so have a null potential



S1 Spherical trees scenario potential

S2 No trees scenario potential

S3 All asphalt scenario potential



S1- DS Absolute potential difference



S2 – S1 Absolute potential difference







Parametric modelling & Data treatment



are modelled based on their footprints and heights. Surrounding buildings of the area of interest are selected based on height and distance criteria

Bioclimatic strategies & new building blocks Generative definitions of context sensitive blocks and urban interventions are integrated and can be optimised

Ladybug Honeybee

UrbaWind

ANALYSIS

& simulation of the outdoor and indoor conditions

A second second second

complex relationships between form and The environmental performance are analysed thanks to several mathematical models with different level of fidelity. All analysis models use the unique parametric synthesis urban model so that any **morphological**, topological or data change will influence the whole data.

Thermal, solar & airflow The dynamics of the urban microclimate and its effects on outdoor and indoor conditions is captured by using **specific** simulation tools (UrbaWind for the CFD airflow, Radiance for solar irradiation, EnergyPlus for indoor and outdoor thermal conditions)

A3



ghness length; z0 (m)





S4 Lambertian ground scenario potential



S5 First surrounding scenario potential



S6 No surrounding scenario potential





1273 0.0% 0.0% 0.0% 0.0% 0.0%

S5 - S4 Absolute potential difference



S6 – S5 Absolute potential difference





Morphology

indicators such as building intensity (FSI), coverage (GSI) and spaciousness (OSR) are calculated at the neighbourhood and urban scales to link form with performance



Climate

While the daily profiles of maximum and minimum extremes give suitable indications when design conditions should be taken into account; average daily profiles represent good conditions criteria for balanced design

Airflow Top: directional morphometric estimation of the frontal area and roughness length Bottom: regional wind rose and simulated wind speed coefficient (90° wind)



Solar potential Annual solar potential mapped on 3D and categorised potential of the facades



Outdoor and indoor thermal comfort Time-specific UTCI map and indoor adaptive thermal autonomy map for January **S7** Unsampled terrain scenario potential



S8 Flat terrain scenario potential



S7 – S6 Absolute potential difference



S8 – S7 Absolute potential difference

This parametric study demonstrates how the conjunction of simulation and parametric modelling can inform a digital design process with precise mapping of microclimatic conditions. Here the link between form, materiality and solar potential is sequentially represented and shows the importance of modelling practice. From this case, the integration of trees and appropriate ground material could represent significant strategies to reduce the local UHI effects due to solar collection.