GENIUS: A tool for multi-disciplinary and multi-scalar databases

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Cities and energy, disease or cure?
Cities are the biggest consumers of energy due to the concentration of human activities on their territory. But life in cities seems to be the best way to preserve the environment and save natural resources.

A multidisciplinary question
To assess the question of energy consumed and produced at the city scale, a multidisciplinary approach is required. In particular, energy balance models must be coupled with microclimate simulations.

A multi-scale question
Coupling models goes with multiple spatial scales. The evolution of the city and of the climate also involves multiple temporal scales (from yearly analysis to simulations of towns’ evolutions over a century).

Conclusion: A lack of multi-scaled urban databases for multidisciplinary research

The map is validated with 91% of correlation

Then, the clustering method K-mean is used to identify 7 types of blocks in the city.

We ran a principal components analysis to select relevant indicators. A statistical analysis of those indicators allowed us to identify 7 typical blocks.

A GIS based method

STEP 1: Transform existing maps of Paris and Toulouse into archetypical maps
Archetypical maps are grids of 250 m x 250 m in which the urban form is composed of “typical blocks” i.e. archetypes of urban blocks that can be found in most European cities.

About 50 morphological indicators calculated on Paris and Toulouse... in order to identify those typical blocks: - Height - Standard deviation of height - Built-up density - Population density - Compactness - Contiguity, - Road surface, - ...

A validation of urban databases for multi-disciplinary research

STEP 2: Set rules to predict urban evolutions
SLEDUM simulates the city sprawl year after year until 2100 as well as the evolutions in built-up density. GENIUS predicts the evolution of morphologies based on SLEDUM outputs and on previous maps.

Paris sprawl simulated by NEDUM:

2010 2030 2100

COUPLING

STEP 3: Set rules to predict the architectural evolutions
First set of rules: Typology
For different prospective scenarios, we make a correspondence between built-up density and typologies.

Second set of rules: Morphology
For a given scenario, we make a correspondence between built-up density and morphological indicators: height, area of road, area of vegetation, compactness, ...

Technical parameterization
According to its age and type, we attribute technical properties to the buildings (thermal insulation, H&V systems, ...)

Correspondence between density and typologies

Evolutionary databases for prospective studies

Inhabitants’ behaviors,
Building materials and thermal properties,
Building equipment (H&V systems)...

At neighborhood scale for microclimate models:
- Surfaces of roads, roofs, walls.
- Surfaces of vegetation and water,
- Height of urban canopy layer...

Evolutionary databases for prospective studies

To assess the question of energy consumed and produced at the city scale, a multidisciplinary approach is required. In particular, energy balance models must be coupled with microclimate simulations.

A tool to compare different scenarios
GENIUS allows to compare different scenarios of socioeconomic development and town planning governance. For instance, we compared the evolution of Toulouse for different scenarios: business as usual, compact morphology, vertical morphology, ...

We can now assess which morphology, the smallest sprawl, the largest space for green areas ...

A multi-scaled urban database for multidisciplinary research

The maps are used for microclimate simulations as well as building energy balance simulations.

A validated urban database

The map is validated with 91% of correlation

AN EVOLUTIONARY URBAN DATABASE