embryo-project | Architecture
Poster 1/2

StreetAAPS

CiAUD Centro de Investigação em Arquitetura, Urbanismo e Design
FCT Fundação para a Ciência e a Tecnologia

Street Facades as Architectural Activators of Public Space – Facades of the Urban Void

Principal Investigator / PI
José Nuno Beirão

Integrated Researchers of CIAUD
David Vale / Ljiljana Cavic / Victor Ferreira / Francisco Serdoura

Collaborating Researchers of CIAUD
Rui de Klerk / João Paulouro / Rogério Lima

External Researchers
Pirouz Nourian, Rusne Sileryte (TUDelft) / Jorge Gil (Chalmers UT) / / Elif Ensari, Mine Ozkar (IstanbulTU) / Anastasia Koltsova (ETHZurich)

Keywords
CIM / Spatial Analysis / Façades / Public Space / BIM

Partner Institutions
TUDelft / Chalmers UT / IstanbulTU / ETHZurich

Expected Future Partner Institutions
Unicamp – Campinas (Gabriela Celani, Marcela Sousa)

UFC Fortaleza (Daniel Cardoso)

STUD – Singapore (Bige Tunçer)

OBJECTIVES

The main objective of the research is to improve streets and public space quality and sustainability in general by improving the plinth and façade design as architectural activators of public space.

The main objective requires a set of complementary objectives:

- Implement street plinth and façade assessment tools (including porosity, permeability, territorial depth);
- Implement tools for public space assessment including plinth and façade data together with spatial analysis tools (including spatial analysis, CSV analysis tools, public space performance tools – environmental (solar / wind / heat island) performance / multi-modal traffic performance / green coverage);
- Implement a street parametric design tool integrated with many analysis tools including CSV analysis. The idea is to develop a design tool capable of generating real time support data to be applicable both on street design and street refurbishment as well as on walkability studies;
- Develop CSV and new public space theory.

BIBLIOGRAPHIC REFERENCES

[1] de Klerk, Rui, & J. N. Beirao. 2017. "CIM-St: A Parametric Design System for Street Cross Sections." In G. Çagdas, et al (Eds.) Future Trajectories of Computation in Design [CAADFutures 2017, Proceedings / ISBN 978-975-561-482-3] Istanbul, Turkey, p. 112

[2] Beirão, J. N. (2012). CItyMaker: Designing Grammars for Urban Design. PhD Dissertation. Delft, The Netherlands: Faculty of Architecture, TU Delft. ISBN 978-1479355020

[3] Sileryte, R., Cavic, L., & Beirao, J. N. (2017). Automated generation of versatile data model for analyzing urban architectural void. Computers, Environment and Urban Systems, 66, 130–144

[4] Beirão, J. N., & A. Koltsova. (2015). "The Effects of Territorial Depth on the Liveliness of Streets." Nexus Network Journal 17 (1): 73–102. https://doi.org/10.1007/s00004-014-0233-5

[5] Ensari, E. (2020). An Uninterrupted Urban Walk: 3D Analysis Methods for Supporting the Design of Walkable Streets. PhD Dissertation, Istanbul Technical University and University of Lisbon

ABSTRACT + IMAGES

Public space is shaped by Architecture. Spatial continuity contained by aligned Architecture defines the street. Furthermore, the degree to which a street becomes an interesting and vibrant place depends very much on the qualities of the facades that shape the street, namely, on the qualities of the plinth ('ground floor' following Jan Gehl's term), in particular, on its diversity, continuity, porosity, permeability, mixed-use and design quality (among other factors). Designing good streets is partially determined by designing good plinths and more extensively by designing good facades. Even street safety depends on this.

The main objective of the research is to improve streets and in general public space quality by improving the plinth and façade design as architectural activators of public space.

The research departs from a set of prototype software – CIMStreet [1], CItyMaker [2] and CSV analysis tools [3] – and plans to integrate all the tools into a single multipurpose design and evaluation tool capable of generating public space design and urban plans with support data imported from georeferenced databases.

[1] and [2] are urban parametric design tools that integrate real-time analysis capabilities used to support decisions. These tools are partly integrated and will be upgraded by integrating additional software developed by Beirão and Koltsova [4] for analysing the impacts of architectural territorial depth on public space dynamics.

[3] Convex and Solid Void (CSV) tools are 3D spatial analysis tools based on space syntax theory, specifically on convex space analysis, but extended to 3D capabilities by comprising 3-dimensional data on public space container facades augmented by available GIS data. These tools are particularly adequate for spatial analysis at neighbourhood scale and can easily compute analysis including façade design information and analyse its impact on the public space by assessing the topological properties of the spatial relations between public and private space.

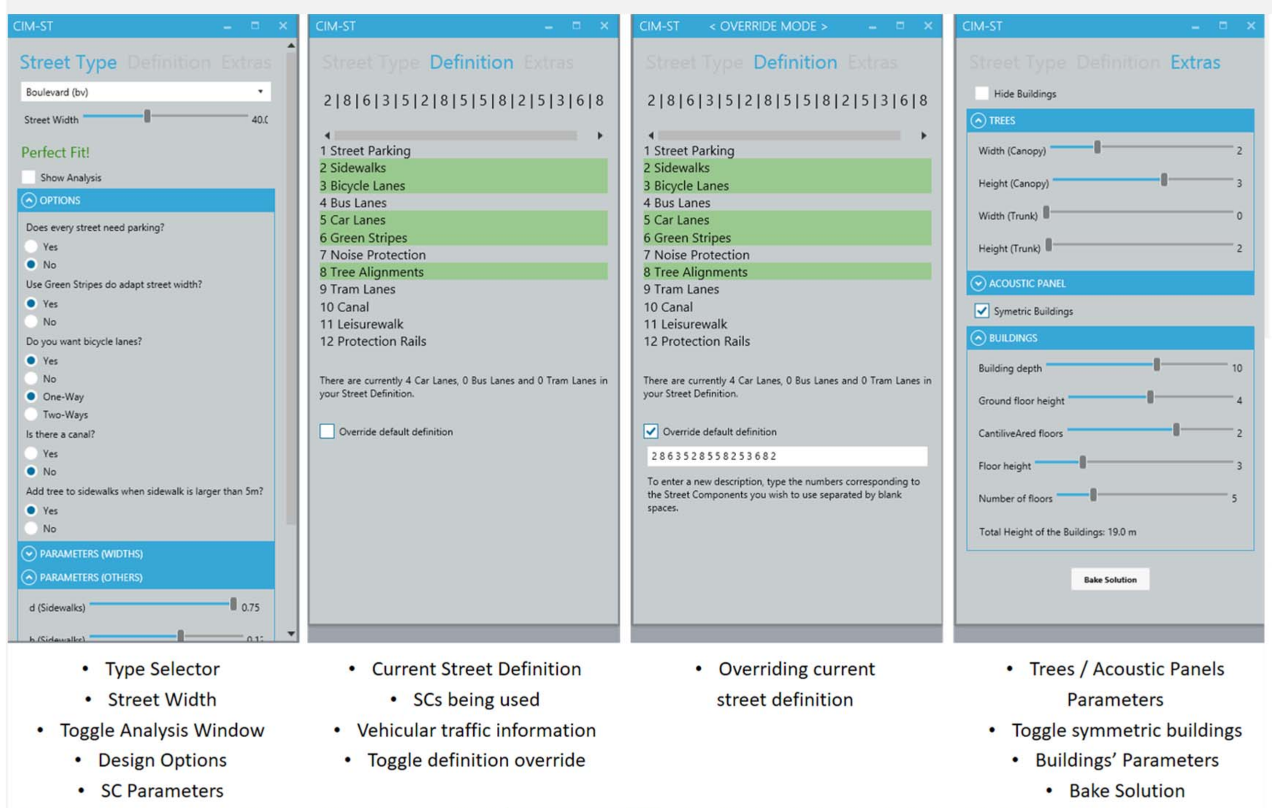
Evidently, facades are essential interfaces for the development of positive and vibrant public space and consequently of good vibrant cities. However, urban plans are not enough to assure such qualities if they exempt themselves from exerting regulatory efforts on the architectural interface, i.e., on façade design. The research plans to develop tools to help the design of public space including the design of facades (possibly given as regulatory architectural constraints in a plan). These tools will incorporate analytical apps that provide evidence to support the regulatory constraints.

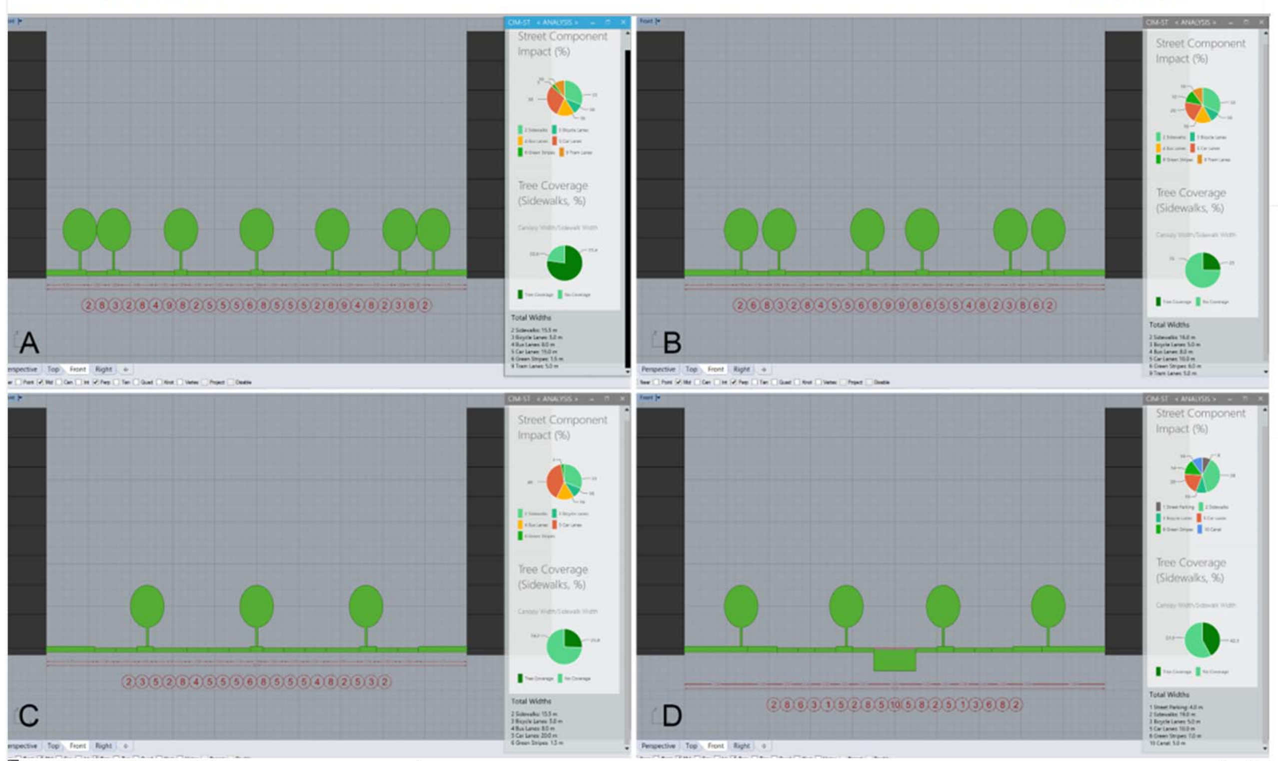
The envisioned tool shall be able to:

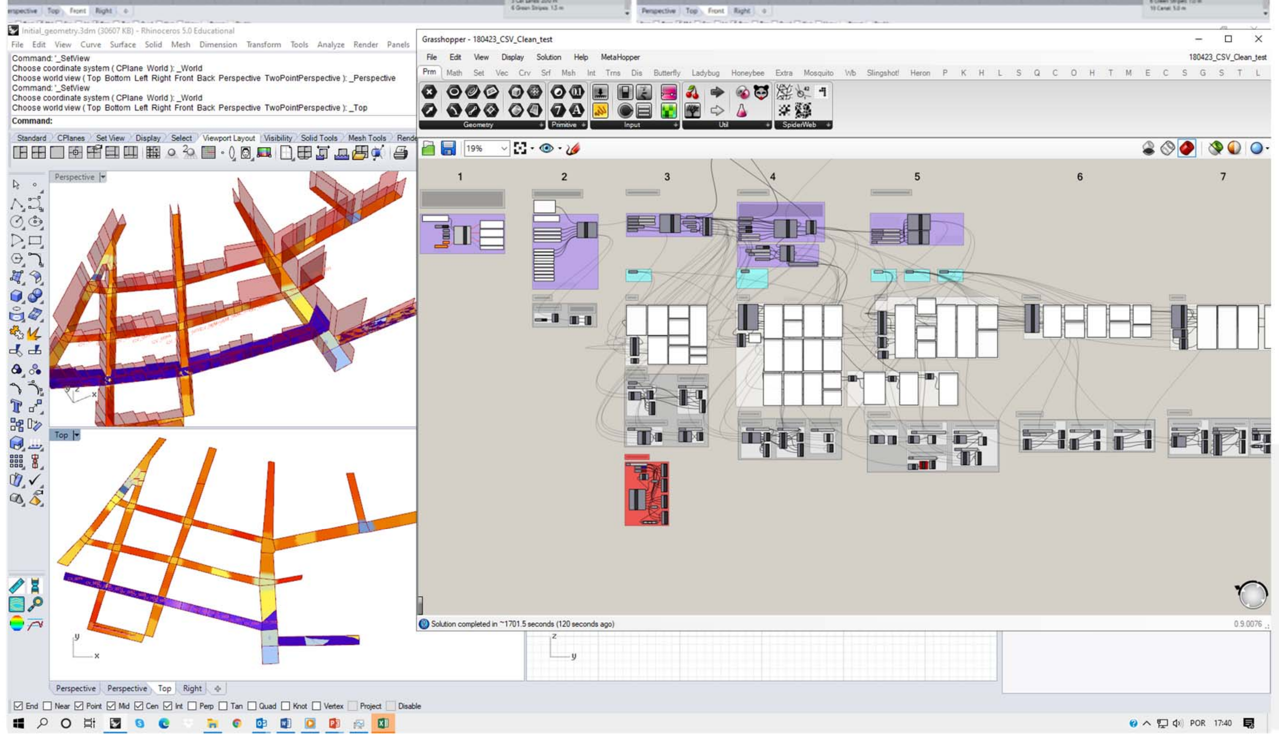
- Generate 3-dimensional representations of public open space called CSV – these representations constitute the data and representational model for analysis;
- Measure and evaluate the impacts of façade diversity, continuity, porosity, permeability, mixed-use and design quality on street vibrancy and liveliness through appropriate indicators;
- Measure and evaluate field based properties, network (topological) based properties and shape based properties of public space;
- Measure and evaluate visual fields, material effects and impacts in space, impacts of objects and other entities in space, variations on heat island effects based on surface materials and drainage capacity including its design control;
- Study public space natural surveillance systems;
- Develop walkability and eco-transportation mode studies;
- Design street cross-sections and public space in general.

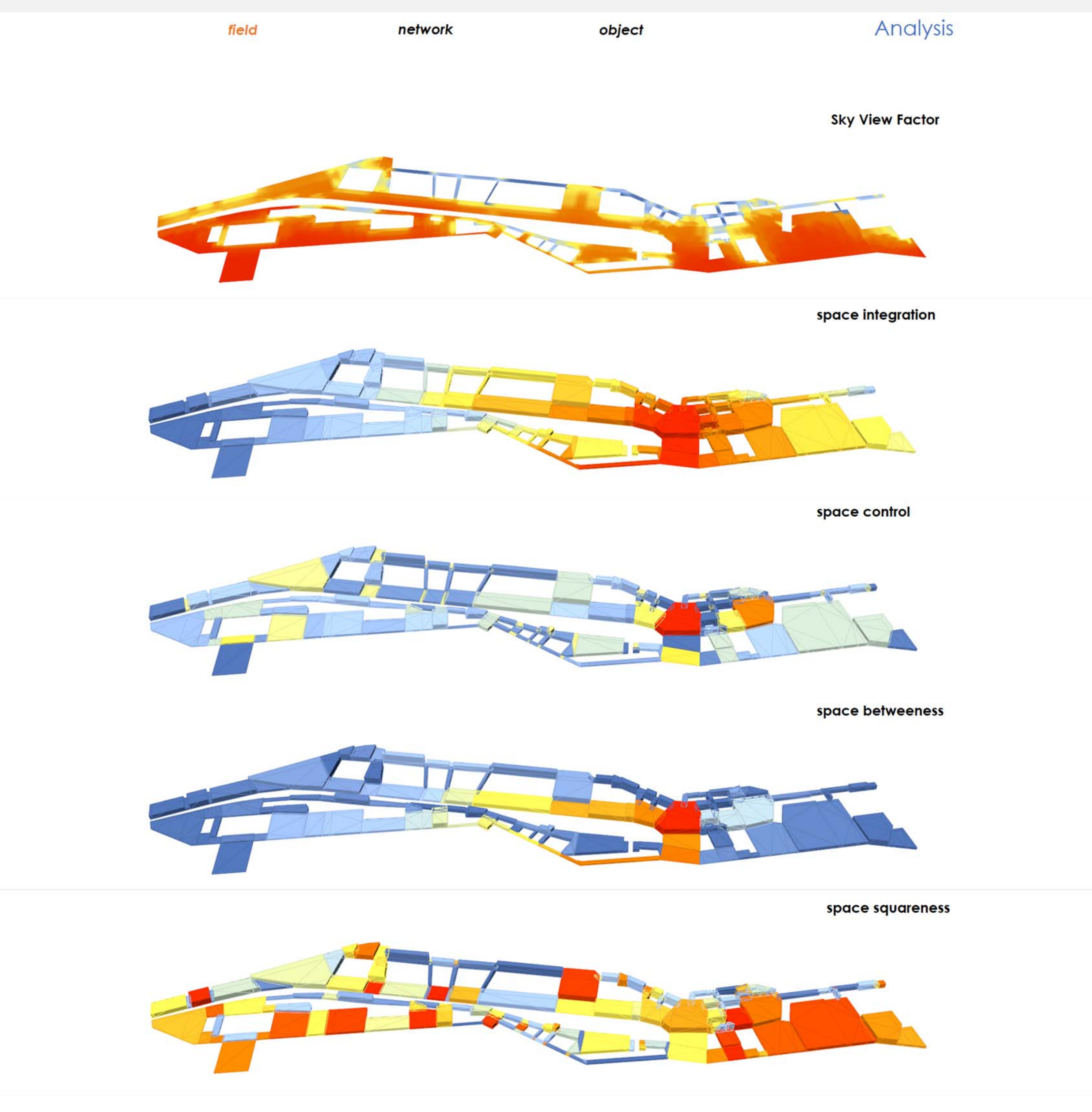
Additionally, we plan to develop new theories on public open space with a particular focus on CSV theory which is an innovative research field. CSV is a new method for studying public space at many different levels, from visuality (cognitive perception), sustainable behaviour, to urban dynamics and walkability in relation to design. It is also an objective of the research project to establish the theory in international terms by developing a European research project application. To do so, we plan to involve other international researchers that had previous involvement in research with this project's PI, namely Pirouz Nourian, Rusne Sileryte (TUDelft) / Jorge Gil (Chalmers UT) / Bige Tunçer (NUS - Singapore) / Elif Ensari, Mine Ozkar (Istanbul TU) / Anastasia Koltsova (ETHZurich).

Convex Voids are convex 3D informed representations of public space that take façade heights as containers of public space to extrude their volume. Solid Voids are aggregations of Convex Voids occurring when there is (1) continuity between spaces given by a low angular deviation; (2) continuity between spaces given by low vertical deviation; and (3) connectivity between spaces given by similar scale of shared boundaries. Condition (1) recognizes natural flow continuity even in winding streets. (2) distinguishes street parts broken by topography (e.g.: San Francisco streets). (3) breaks continuity between spaces with a different scale distinguishing between streets and squares.







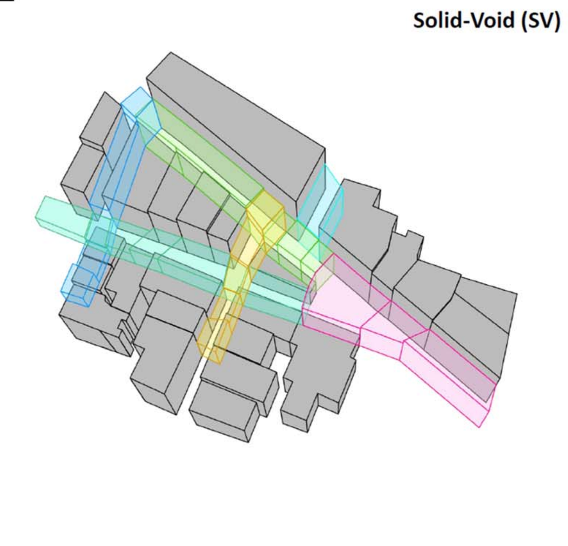


Geometric measures

Property Key	Explanation
CS_Area	CS area
CS_Diameter	Diameter of largest inscribed circle within a CS
CV_Height	CV height
CV_Volume	CV volume
SV_Area	SV footprint area
SV_Perimet	SV perimeter
SV_Entranc	Number of intersecting SVs
Fac_Width	Width of façade face
Fac_Height	Height of façade
Flow_Length	Length of flow segment
Flow_Incline	Slope of flow segment
Cv_Compactess	(CV_Perimet*CV_Height)/CV_Area
Cv_Squareness	CV_Area/Area of smallest bounding square
Cv_Enclosure	Tot_FacWid of CV/Total CV Perimeter
Cv_Openness	1- Enclosure
Cv_SkyViewFactor	% unobstructed vision rays originating from points within CV

(source: Elif Ensari, 2018)

Solid-Void (SV)



Figures

Left – Fig. 1 and 2 – CIM-Street interface (1) Inputs; (2) Outputs // Fig. 3 – CSV interface

Right – CSV Outputs – mapping of attributes and sample of calculated attributes embryo-project | Architecture

Poster 2/2

StreetAAPS

CiAUD Centro de Investigação em Arquitetura, Urbanismo e Design

FCT Fundação para a Ciência e a Tecnologia

SCIENTIFIC RELEVANCE FOR THE DISCIPLINE

CSV theory is an entirely new concept for the analysis of public space that has been developed under the supervision of the PI. At the present stage, the theory shows very high potential to develop studies on public space by using a new theory supported by tools developed to facilitate an in-depth understanding of public space dynamics.

Although founded on space syntax this 3D approach does not replicate the original theory; on the contrary, due to 3D detail it brings new possible fields of research at street, public space and neighbourhood levels, namely: walkability studies, spatial cognition and cityscape arousal studies, studies on architectural activators of public space and their attributes (plinth, façade porosity, permeability, territorial depth and other attributes), dynamics environment and public space sustainability studies. In a nutshell, the project shall produce a new theory (and respective analysis tools) for street and public space studies (including design tools).

EXPECTED ECONOMIC AND SOCIAL IMPACT

The new theory and respective analysis and design tools are foreseen to help refurbishing and designing better, more resilient and more sustainable streets and public space in general. The are expected to give better insights on most present paradigms of public space design, like improvement of pedestrian use of public space, improving safety, economic dynamics of public space, reduce the impacts of climate change (reduction of CO2 emissions, increasing soil permeability and evapotranspiration, heat island reduction and other measurable factors), improvement of plinth design and architectural facade design in general (by building a theoretical consciousness on the impacts of facade design on street dynamics including safety perception).

With these tools and methods we expect to invert the 'city for cars' paradigm into a 'city for people' paradigm and especially the negative impacts that modernist paradigms of building and facade design have imposed to public space and their social dynamics.

RESEARCH PLAN AND TASKS

CSV theory is an entirely new concept for the analysis of public space. It develops a representation model of the urban void and analyses the properties of public space kept within the 3D representations. Convex Voids are derived from convex 3D informed representations of public space. Contrary to space syntax traditional convex spaces which take for definition the fattest spaces (spaces with the fattest inscribed circle), convex 3D informed spaces resort to a 'fattest + squareness' algorithm to generate their representations based on an aggregation of triangles, which is able to recognize two streets crossing as individual spaces defined by the street corners. They are informed because they derive from geographic information and therefore can have associated data, plus additional information derived from analytical procedures. And they are 3D informed because they contain information on elevation, slope, boundary elevations and neighbour spaces (plus inherited GIS information). The elevation data is used to generate an extrusion of the convex space into a three dimensional representation called Convex Void.

Solid Voids are aggregations of convex voids. Aggregations occur whenever 3 conditions are satisfied: 1) continuity between spaces given by a low angular deviation; 2) continuity between spaces given by low vertical deviation; and 3) connectivity between spaces given by similar scale of boundary share. Condition 1) keeps natural flow continuity even in the case of winding streets. Condition 2) distinguishes street parts broken by topography (e.g.: San Francisco streets, although linearly continuous break at hill tops distinguishing two visually independent sides of the same street). Condition 3) breaks continuity between spaces with a different scale. The latter condition allows the distinction between streets and squares.

The existing tool prototypes were programmed mostly in Python (but also to visual programming - Grasshopper) and implemented as new extensions of existing open source software. The complete software set follows the concept of City Information Modelling (CIM). A CIM platform is composed of a geographic information system (GIS), a spatial database (DB), a parametric design interface and a set of analysis tools (independent or integrated as plug-ins). At the moment, we use only open source software with the exception of Rhinoceros. We are also planning to add BIM (Building Information Modelling) integration which is mostly already available through Rhinoceros (with Revit, ArchiCAD and VisualARQ) and Python. The tools will translate 3D data into BIM objects and augment them with analytical and collected data, providing a new source of BIM information to end-users.

The existing tools, [1], [2], [3] and [4] are not yet integrated. [1] and [2] constitute a basic CIM. [3], CSV, is built over a CIM structure. [4] could be adapted into a CIM analysis plug-in. [3] tools will be used in our project as the generator of the CSV representation model, which will be the basis for the spatial data storage and therefore for the spatial analysis. This software is working and used in a space syntax education program, but the software still requires consistency improvements. The procedural instructions for the use of the software are given in a tutorial page, also used to support the lectures (http://solidvoids.fa.ulisboa.pt/tutorial/). The CSV model contains a network of convex voids and a network of solid voids that can be used to study public space by analysing their topological properties, integrated GIS data, and the facades BIM data. CSV theory has been until now built over the existing tools and graph theory by analogy with space syntax theory. However, this theory is envisioned by their main developers not as an overdetailed space syntax theory but as a new theory for public space analysis at neighbourhood and street scale. This theory is at the moment supported by 5 papers and 2 PhD Theses. The theory points several future uses like: urban visual cognition studies; walkability studies; urban natural surveillance; or urban activation through façade design. This theory also requires consolidation.

The research plan contains 2 main phases: 1. Software improvement; 2. Theory building and consistency.

Phase 1 departs from accumulated data collected from the existing education program and encompasses the following tasks (Tx):

- T1 – Systematization of software bugs, inconsistencies and incompatibilities. Systematization of data model inconsistencies, errors, geometry inconsistencies (and exceptions), and data mismatches.
- T2 – Tolerance testing. The representation model is generated according to several pre-set tolerance values that require consistency evaluation. At the moment, tolerances are open variables. From the urban analysis viewpoint it would be preferable to work always with the same tolerance inputs in order to generate comparable models, but the fixation of the tolerance values requires evaluation and validation. For this purpose, we will need to A) select a number of case study areas; B) identify all existing paradigmatic situations (where tolerances apply); C) develop a simplified study area including all paradigmatic situations (to accelerate computational time); D) evaluate results for consistency over a set of predefined criteria.
- T3 – Standardization of data storage procedures and data structure.
- T4 – Software optimization.
- Previous tasks refer to the generative functions generating the representation model. The following tasks refer to the development of analytical functions and they represent Phase 2.
- T5 – Separation of analytical tools from generative tools foreseeing two types of users (possibly with separate interfaces).
- T6 – Literature review. Identification of indicators of public space dynamics that can be calculated with CSV models (topology based indicators, diversity, plinth, environmental, walkability indicators among others). The literature review should help to start from a relatively consistent set of indicators organized per research topic establishing relations between indicators and their meanings developing a qualitative interpretation theory. Future accumulated evidence should support or deny the theory.
- T7 – Following tasks 2 and 3, develop a large data structure with indicators and attributes calculated for the entire set of case studies plus the simplified model. Data normalization. Statistical search for data reduction and data patterns. Data classification. Identification of relevant data for specific research topics – establishing relations between types of results and their theoretical interpretations. Task 7 will follow 5 main research lines: (1) spatial cognition; (2) public space networks and syntax; (3) walkability studies (and other transport modes); (4) public space sustainability, environmental and smart city studies; and (5) street facades as Architectural activators of public space (plinth studies).
- T8 – Book on CVS theory.

EXPECTED SCIENTIFIC RESULTS

Results expected at 2 related domains: 1) software development; 2) public space dynamics theory.

1) Development and preliminary validation of an urban analysis and design tool merging CIMStreet [1], CItyMaker [2] CSV analysis tools [3] and plinth architectural interface analysis [4] (with BIM façade components).
2) Development and publication of new public space dynamics theory on the following topics:
   a) CSV models of public space and respective theory (topological properties of public space; 3D derivations of space syntax theory for street and neighbourhood analysis);
   b) Street facades as architectural activators of public space (plinth and façade porosity, permeability and territorial depth – implications on street dynamics);
   c) Walkability studies – implications of the plinth architectural interface on the pedestrian use of streets and other public spaces;
   d) Spatial cognition and cityscape arousal studies resorting to CSV analysis;
   e) Environmental and sustainability studies.

BUDGET: € 7.423,34

This embryo project is requesting funds to support the collaboration of a grant holder for the period of 6 months to help develop the application for (preferably) a European research project (possibly and additionally an FCT project). The role of the grant holder is to help the planning of the European research proposal, keeping data, organizing contacts and meetings (planned team integrates European researchers involved in previous collaborations), budget calculations and management, keeping order and contents for proposal versions.

The grant follows the values given by FCT (for a researcher with a master degree), 1064.00€, plus insurance, 129.89€ per month and the accidents' insurance with the total value of 60.00€. The total value is: (1064.00+129.89) * 6 + 60.00 = 7223.34€

Additional value for current printing of 200.00€ (including coloured prints).

Total budget: 7223.34€ + 200.00€ = 7423.34€