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# Parametric Architectural Design for a New City Identity: Materials, Environments and New Applications

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## ABSTRACT

*In contemporary architectural Design, we speak of a parametric structural design. A design that integrates new functionalities crossed with the spatial geometry of objects. It has been considered structured because it optimizes combinations that integrate a minimum of materials and data to respond to functions, uses, and needs more adapted to a society in perpetual evolution. Parametric modelling allows the usability of new materials and the integration of new structures in a variety of design environments. This transdisciplinary research explores aspects of parametric modelling, a design method that creates digital models using algorithms and parameters. By focusing on the material and immaterial plurality of the designed space, this method enables the generation of complex and innovative forms that would be difficult to realize with traditional methods. Then, from a position that redefines the city as both a "medium" city and an "object" city, we explore the fields of application and novelties that are investing in the fields of architectural construction. We examine how parametric modelling can be used to create more sustainable and environmentally efficient buildings, using parametric processes, and optimizing the use of space. In this sense, our research will lead us to identify two aspects of parametric modelling: the conceptual parametric design aspect and the constructive parametric design aspect. Finally, the results of our research enable us to identify a design process that demonstrates the feasibility of using parametric modelling to generate viable, sustainable, and versatile spaces.*

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## Highlights

- This paper explores the fundamentals of parametric design as an innovative digital environment for architectural design
- It captures the architectural specificities of the city of Tunis through parametric modelisations.
- It highlights the conceptual and constructive specificities of the city's architectural design
- Emphasizes the importance of participatory design in the architectural design process to create more inclusive and sustainable urban spaces.

## Contribution to the field statement

The article contributes to the field of architecture and urban planning by exploring innovative approaches to design, sustainability, and city identity, while also advocating for a more inclusive, human-centered, and participatory design process that considers the well-being and preferences of local communities. These contributions have the potential to positively impact the social and cultural fabric of cities and their inhabitants. Overall, this manuscript provides a significant contribution to the existing literature on parametric architectural design and explores the importance of participatory design in the architectural design process. By involving stakeholders from the beginning of the design process, this approach makes it possible to create urban spaces that are more inclusive and responsive to the needs of local communities.

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## 1. Introduction

Our research focuses on exploring the potential of parametric architectural design to define a new urban identity. Parametricism is thus growing up and becoming serious about making an impact in the world (Schumacher, 2016). We focus on using parametric modeling to create buildings that are responsive to user needs while being environmentally and socially sustainable. By using algorithms and parameters to generate digital models, architects can create complex and innovative forms that would be difficult to achieve using traditional methods (Kelly, 2014). We also seek to bring together elements that could consolidate the new parametric modeling experiments developed by designers and researchers in spatial geometries with the new constraints of architectural construction. The computational grasp of parameter-dependent processes of emergence and transformation is also a winning proposition in the field of urban planning and design (Schumacher, 2016). Therefore, this paper examines how parametric modeling can be used to optimize the construction and fabrication of new buildings, using environment-friendly materials, and optimizing the use of space. Finally, we seek to create a homogenized and improved spatial interpretation and identification of the city using parametric modeling. By focusing on the material and immaterial plurality of the designed space, this method generates complex and innovative forms that reflect the unique identity of each city. An identity constructed according to ambivalent criteria based on the architectural space's use and functionality. This territorial identity matches together natural identity elements which are related to the natural environment data of the city, with human identity elements which are the individual and the society, both are linked to the artefactual identity elements identified as arrangements made in a city (Sönmez, 2020). The results of our research identify the crucial role of parametric modeling as a design process in generating viable, sustainable, and versatile spaces for the cities of the future. Parametric architectural design is an innovative approach in the field of architecture that is intended to create buildings and public spaces using advanced digital tools. It is founded on the use of parameters that control all aspects of an architectural project, from geometry to environmental performance. This approach aims to design buildings and public spaces that are relevant to environments and communities and can reflect a sense of belonging and experience. The word 'architecture' seems to mean both a thing and an activity. On the one hand, it seems to imply buildings with certain 'architectural' attributes imposed on them. On the other, it seems to describe what architects do, a certain way of going about the process of making buildings. (Hillier, 2007). By modeling the architects' designers can include various parameters such as topography, natural light, wind, materials...etc. Computer modeling is a method of virtual representation that provides a form of electronic prototyping. It allows ideas to be developed, described, visualized, and evaluated in terms of environmental performance without the expense of actual construction or the time-consuming task of producing drawings (Frazer, 2016). In that sense, we have decided to study parametric architectural design to define it in a specific context related to the methods of conception, to the construction environments, and especially to architectural city modelization. This involves, among other things, a search for an answer to the following questions:

- How can parametric designing with new architectural software include essential algorithms for optimizing the configuration and enhancement of a project?
- What are new investigation environments that parametric design explores to optimize the lived experience in the city?
- What are the distinctions between conceptual parametric design models and constructive parametric design models?
- Should a city's architectural sustainability depend more on the preservation of its environment or its constant updating through design parameters?

### 1.1 Methodology

Our research is divided into four parts and is based on a mixed methodological approach that combines theory and practice. First, we define the properties of parametric modeling by reviewing different design methods that use algorithms and parameters to generate numerical models. We'll explore how



this method can be used to create more sustainable, efficient, and aesthetic buildings. Next, we'll begin an explanatory section devoted to architectural application environments and their dimensions. We'll look at how parametric modeling can be used to optimize the construction and fabrication of structures, using specific materials, and optimizing the use of space. We will also explore ways in which this method can be used to design buildings that fulfill users' needs while being environmentally friendly and viable in a sustainable way. Third, we will distinguish between the characteristics of the city as a "medium" and the city as an "object" (Table 4). We will examine how parametric modeling can be used to create complex and innovative forms that reflect the unique identity of each city. We will also explore how this method can be used to create more citizen-friendly public spaces. Finally, we will discuss a new architectural vision that includes the user as the first actor in the design of his city.

## 1.2 Aim and Materials

The main objective of this research is to explore how parametric architectural design can be used to create a unique identity to achieve a participative appropriation of the city. This approach involves focusing on the materials used in construction, the environments created by architecture, and possible new applications with parametric design. It's about bringing together our most distinctive and cohesive architectural and participatory elements into a strong and meaningful city statement. The socio-economic and territorial development of a society can be significantly influenced by exploring parametric architectural design to create a unique identity for a city. By creating a city with strong, coherent urban planning, it is possible to support and strengthen the cultural identity of the city. This identity can be shaped by elements such as architecture, parametric planning, the arts, and citizen participation. Encouraging community participation in the creation of this identity can strengthen residents' sense of belonging. Through a cartographic study specific to the city of Tunis, we aim to highlight architectural and environmental dimensions that actualize aspects of the user amenity experience. A parametric demonstration based on programs, plugins, and presenting architectural indicators will be implemented. We will examine how the usability of materials and new algorithms can be linked to inclusive parametric architecture and connected society. The following illustration (Figure 1) outlines the specific methodology process required to put this research into action. It represents a frieze that defines the starting point of our research which is based on the literary modalities that define parametric architectural design. This methodology is then divided into two distinct levels: the first involves imagining and drawing digital models, while the second involves imagining and making these models. By exploring these two different design phases, our research aims to identify the advantages and constraints of parametric modeling. A transition is highlighted to link definitions and theory to a qualitative state of art that reveals the city as a duality inscribing a conceptual-environmental and constructive-architectural schematization. After testing and displaying mapping simulations focused on users' experiences in the city of Tunis, its way findings, and amnesties, (figure 5) designed to demonstrate the value of social and architectural inclusion; we'll be able to identify the key factors for a better parametric architectural design. An original architectural parametric design for the city will be suggested, integrating all social specificities, and enhancing functionality and usability for a more interconnected society.

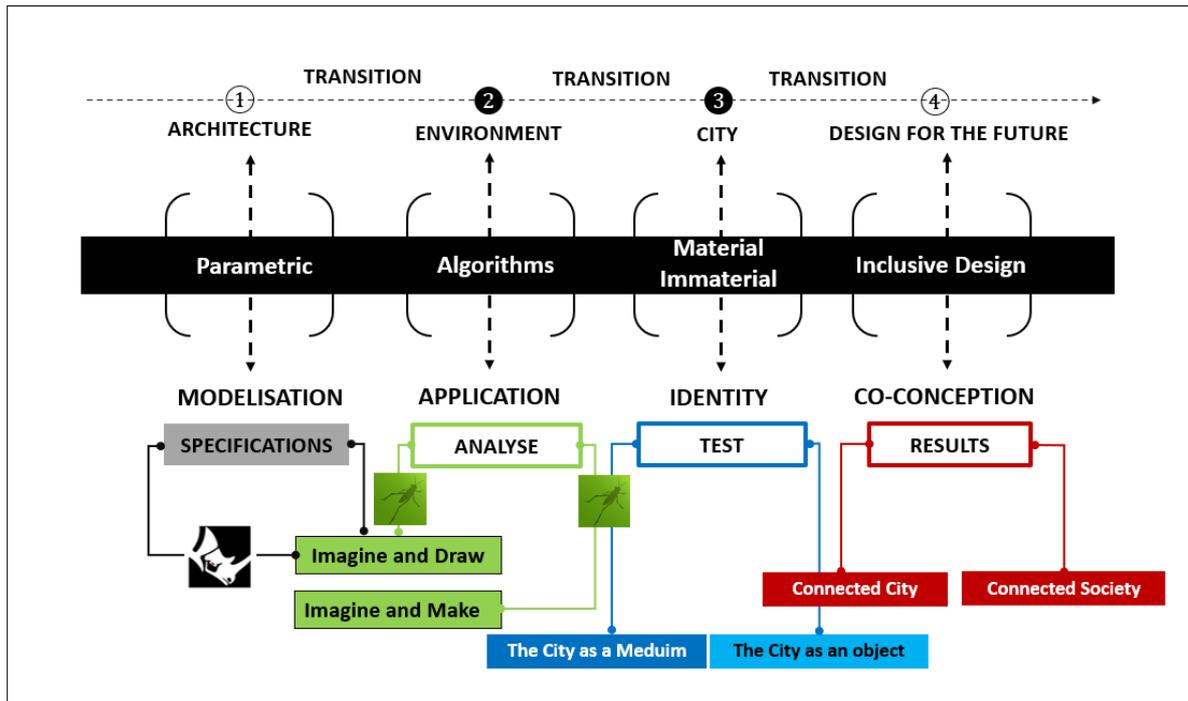


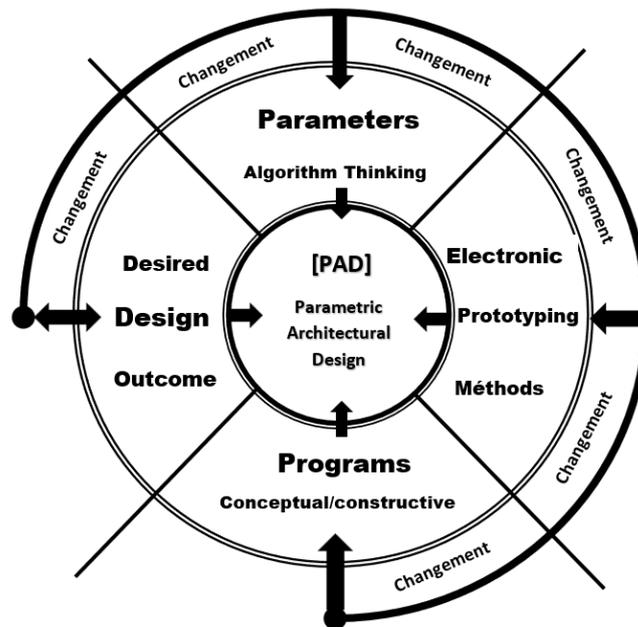
Figure 1. Methodological process.

## 2. Theoretical Background: The fundamentals of parametric design

One of the most profound aspects of contemporary architecture is not the rediscovery of complex curving forms, but the newfound ability to generate construction information directly from design information through the new processes and techniques of digital design and production (Branko, 2003). Otherwise, to encapsulate the cardinal principles of parametric design we adopt through this research a multidimensional approach that links parametric architectural design to definitions identifying theory and practice. This chapter has the merit of focusing on new parametric architectural design methods, which attempt to redefine the dimension of research/design in both an epistemological and digital context. The epistemological aspect is seen through the modeling processes and the numerical aspect through the new architectural principles of parametric realization. The fundamentals of parametric design are explained in this section according to a reading direction identifying the birth of the parametric architectural notion through different interpretations and reasonings. Etymologically, parametric design is a paradoxical term. The adjective "parametric" refers to parameter, which comes from the Greek "para", signifying a subsidiary or assistant, and the term "metron", which implies "measurement". This, in turn, opens two windows on its significance- the one mathematical, reflecting a measurable factor that defines a system or sets the conditions for its operation, and another that is more general, describing the boundary and scope of a specific process or activity (Semlali, 2017).

Modeling and configuring architectural space have nowadays become a tool that offers spatial experimentation and mutually integrates the user and the architect in a reading and interpretation phase. In this sense, each modeling work requires configured expertise and creativity based on specific architectural knowledge. Digitally modelled representations that handle function and are used to identify constantly changing needs. In this sense, Robert Woodbury states that Design is changed. Parametric modeling represents change (Woodbury, 2010) We highlight the term "change" since it is defined in a computer modeling context; the character of a parametric design project is identified in terms of changes during its realization. The use of relationship programs for generating shapes, fragmenting spaces, and even performing algorithms, constantly invites iteration to be part of the design process. Each modification represents a new parameter setting, and each new parameter setting produces a new creative experience. Alternating tasks that focus on specific spatial prototyping and identifying functionalities and usability. Graphical and parametric exploration is a process that leads the designer into an interactive research phase and allows him to explore a set of solutions to define

his final project. In this same definitional context, (Wassim, Shwe, Peter, Robert, & Simon, 2017) integrates a specific vocabulary that refers to parametric architectural configuration as a kind of prototype, he defines the integration of new programs alternating solutions and combinations between color material and environment as "electronic prototyping" (Wassim, Shwe, Peter, Robert, & Simon, 2017). This dynamic research is methodologically carried out according to the project phases and we can even talk about parametric methods. First, it is a matter of manipulating complex data and mastering programming language to reach the desired design " Desired Design-outcomes " (Helmut, Andreas, Michael, & Kilian, 2009). Next, it is required to carry out what we can describe as "Algorithm-Thinking" (Wassim, Shwe, Peter, Robert, & Simon, 2017) to solve problems by applying parameters. Finally, it is a question of being part of an experimental field for architectural construction prototypes. Prototyped models offer simulations of shapes, materials, textures, and colors and define functionalities and uses. Modeling or simulating are tasks targeting the creation of a thought and a generated architectural visualization. Patrick Janssen (Patrick & Rudi, 2015), defines a parametric model as an algorithm that generates models consisting of geometry and attributes (material definitions). This algorithm uses functions and variables, including both dependent and independent variables. Some of the independent variables can be given a more prominent status, as the interface to the parametric model, these are referred to as the parameters of the model (Frazer, 2016).



**Figure 2.** [PAD] Involving change, (Developed by Author).

Generated architectural modeling is a methodical design in which the insertion of sound images and architectural models is generated from the implementation of several rules depending on a very specific algorithm. Each generated design is configured with a set of modeling parameters. It is a generative design based on algorithmic thinking allowing to apply parameters and rules that altogether define, encode, and clarify the relationship between the imagination of the architectural space and its desirable construction. In other terms, parametric architectural design becomes recognizable according to the intention of the design and the response inventoried algorithmically. We will be able to classify thus on one hand the intention of the design and on the other hand the response of the design. Generative design is becoming increasingly important, largely due to new programming environments (Peters & Brady, 2018), in his chapter "Parametric Environmental Design Simulation and Generative Processes", looks at the intricacies of architectural construction. He underlines the need for architects to navigate in a dynamic digital landscape, using a diverse range of tools for tasks encompassing document creation, communication, graphics, drawing, design, and the use of new information technology tools. He confirms that the development of the programming tool Processing offered another alternative environment in which algorithmic design could be explored and shared with an interested community.



There is a trend in architecture towards parametric design—in which the designers focus their attention on the creation of generating algorithms rather than specific instances. In this paradigm, variants of the design are produced by varying the parameters of the underlying algorithm, and it is in the evaluation of design variants where computer simulation can play a significant role (Peters & Brady, 2018). The description of parametric design basics in this section, helped us to understand that technological innovation based on new digital performance software, is a process that is introducing change for the optimization of architectural and urban planning research. Architects, interior designers, and engineers are faced with a significant challenge: conceptual and constructive, it involves equally thinking and doing. However, according to (Ajla, 2016), design professionals are currently faced with many challenges—rapid technological changes, the necessity to innovate and raise the bar in building performance, and a paradigm shift in architecture. There are several reasons why progressive practices must continuously invest in research and the implementation of advanced technologies, but the need to improve design processes and services is typically the overarching drive (Ajla, 2016).

### 2.1 Software

The second part of our research is dedicated to demonstrating the fundamental role of innovating and creating in architectural design. Using applications dedicated to parametric architectural design, we intend to examine some examples of parametric architectural models identifying the construction drawings of urban cities as mentioned in figure 4 and figure 5. These examples will refer to the interoperability of two environments and are configured using Rhino 3D parametric design software with Grasshopper. To communicate the successful integration of new software into the architectural design environment (Fink & Reinhard, 2019) stated that Rhinoceros 3D is a commercial Computer-Aided-Design (CAD) software developed by Robert McNeel & Associates that bases geometry on mathematical nurbs models (Fink & Reinhard, 2019). Also approved by (Peters & Brady, 2018), who specified that in 2007 the introduction of Grasshopper, a new visual scripting plug-in for Rhinoceros was recognized. The architectural community was ready for an algorithmic design tool, so Grasshopper rapidly gained in popularity. It is financially accessible; it has a vibrant online community, and it makes it easy for designers to create their appropriate design tools. Crucially, in the context of introducing simulation to the digital design environment, what Rhino/Grasshopper has offered is the ability to easily create custom plug-ins. (Peters & Brady, 2018). Interoperability between Rhino 3D and Grasshopper is one of the key features that make them powerful tools for architects and designers. The two programs work seamlessly together, allowing designers to create complex designs that can be easily modified and updated. Rhino 3D provides the platform for creating 3D models, while Grasshopper provides the tools for creating parametric designs. Interoperability between the two programs means that designers can move quickly and easily between them, using the strengths of each to create designs that are both visually stunning and highly functional. The most preferred design software package for 3D modeling and parametric design is Rhinoceros and Grasshopper3d. Rhinoceros is a professional modeling software and Grasshopper is a plug-in for Rhinoceros which provides it with a visual programming environment that is used to define algorithms that automate tasks in Rhino (Apellániz & Vierlinger, 2022).

### 3. Case Study: Environments of architectural applications versus representative dimensions

For the purposes of our research, this section aims to study design environments that generate readings of architectural configurations and identify city-specific parameters (Peters & Brady, 2018) specified that Homes and buildings are in constant negotiation with their immediate environment. The reality of architectural design reveals a constant duality between the building and its environment, on the one hand, and the design process, which can anticipate this duality and thus improve this relationship, on the other hand. Architectural representations and models offer a future vision that can optimize the spatial viability of buildings. They situated the act of drawing as being a predictive act of experimenting with possible futures. The building's architects' design today form the cities of the future. Simulation is a way in which designs can be tested for their future performance. (Peters &



Brady, 2018). As we made clear in our first section when we defined PAD, (Figure 2) parametric simulation depends on a process involving change, an approach linked to two different application environments: one related to concepts and ideas, and the other to algorithm generation and construction. In the context of historical determination (Stavric & Marina, 2011) has identified 1990 as the year when parametric design influenced the development of digital architectural design, where we can distinguish between architectural CONCEPTUAL parametric design (Table 2) and architectural CONSTRUCTIVE parametric design (Table 3), (Stavric & Marina, 2011). These architectural models which are designed with parameters and program synchronizations are the object of virtual representations covering simultaneously invariant entities and contingent entities (Agbodan, Marcheix, Pierra, & Thabaud, 2023) which are algorithmically configured to display architectural spaces. The space experimentation through prototyping or simulating models aims to integrate the user consumer of the building in an atmosphere approximately close to reality. Modeling and configuring the space becomes a tool facilitating the user's experimentation and integrating them at the same time into a reading and interpretation phase. In this sense, each modeling activity requires configured Form-Thinking and creativity based on architectural knowledge. The interaction between thinking and doing will be explained by translating and transforming architectural knowledge into graphic Form-Making representations. Parametric architectural design recognizes the particular characteristics of the city and uses them to create buildings and public spaces that are adapted to the specific features of each neighborhood. The particularity of the city is recognized through its climate, its environmental insertion, its urban structuring, and its appropriation. By configuring and classifying these parameters, Rhinoceros 3D and Grasshopper display the city and connect it with its environment in a way that optimizes its sustainability. Through (Table 1) we set out some examples of the kind of parameters that bring ideas to fruition. These are just some of the plug-ins that are appropriate for the software environment.

**Table 1.** Table Showing parameter classes from, Form-Thinking to Form-Making Design Plugins Assistance.

<b>Classes of Parameters</b>	<b>The Meta-Parameters classes</b>
Parametric Architectural CONCEPTUAL Design	Parametric Architectural CONSTRUCTIVE Design
Form Thinking- Imagine and Draw Structure and format	Form Making – Imagine and Make Combining, synchronizing, and prototyping
Space + Area + Scale+ Measurement Size + Ergonomics + Function	Envelope + Texture + Covering + Walls Usability + Shapes + Contours + Functionality
Lighting-dark/light + Colors + Fashion + Materials+ Climate+ Energy+ Environment	Population + Genome+ Fitness, Selection, Crossing-over + Mutation

[ PAD] Results through visualizations simulations and prototypes.

To create a geometric simulation in Rhino, Grasshopper offers a visual programming function. Users can switch and group nodes between multiple functions to create code that defines what is being created and calculates adequate solutions. That's why this methodology is often referred to as computer modeling. According to Peters and Brady (2018), design simulation can predict building performance by comparing early geometries in terms of energy consumption, daylight, shading, airflow, comfort, sunlight, and other parameters. (Peters & Brady, 2018).

### 3.1 Imagine and Draw, Imagine and Make

Parametric architectural conceptual design is an approach to designing buildings that uses parametric modeling techniques to imagine and then draw 3D models and plans with adjustable parameters. This enables architects and designers to imagine and make (Lafhaj, AlBalkhy, & Linner, 2023), to explore,



and test different design options quickly and efficiently, based on specific design objectives and constraints. The emphasis is on generating a concept, a form that can later be developed into a more detailed design. Parametric architectural Constructive design is an approach to building system design that uses parametric modeling mechanisms to generate detailed, constructive design solutions. It involves the creation of three-dimensional models with adjustable parameters linked to building elements and systems. This enables architects to optimize constructability, structural integrity, material efficiency, and other construction site considerations. The aim is to create a design that can be efficiently translated into a built structure.

**3.1.1 Parametric Architectural CONCEPTUAL Design**

Conceptual Parametric Modeling is an architectural design method that allows architects and designers to create digital models using algorithms and parameters. Using extensions such as Ladybug and Honeybee in Grasshopper, building professionals can design for a specific environment based on climatic and geographic data. This allows architects to configure a climate based on the city, which can help create more sustainable and energy-efficient building designs. Ultimately, conceptual parametric modeling offers an innovative approach to architectural design that allows architects to create more accurate and customized models to meet their clients' needs. The climate simulation of downtown Tunis is a concrete example of the use of parametric conceptual modeling in architecture as shown through (Figure 3).

**Table 2.** Ladybug and Honeybee as two examples of Parametric Architectural CONCEPTUAL Design.

<i>Typical program application</i>	↔	<i>Interoperability with extensions</i>
<p><i>Ladybug is a Grasshopper plug-in for visualizing and analyzing atmospheric data. It provides representations such as sun position and trajectory, wind simulation, psychrometric map, etc., as well as geometric analyses such as radiation analysis, shadow study, and view and visibility analysis. (Energy Plus Weather File)</i></p>	<p>↔ ↔ ↔</p>	<p><i>Honeybee is a Grasshopper3D extension that connects to certified simulation models such as Energy-Plus/Open-Studio for building energy management, HVAC calibration, climate comfort... etc. As regards Radiance for daylight and transparency simulation, Honeybee is a</i></p>

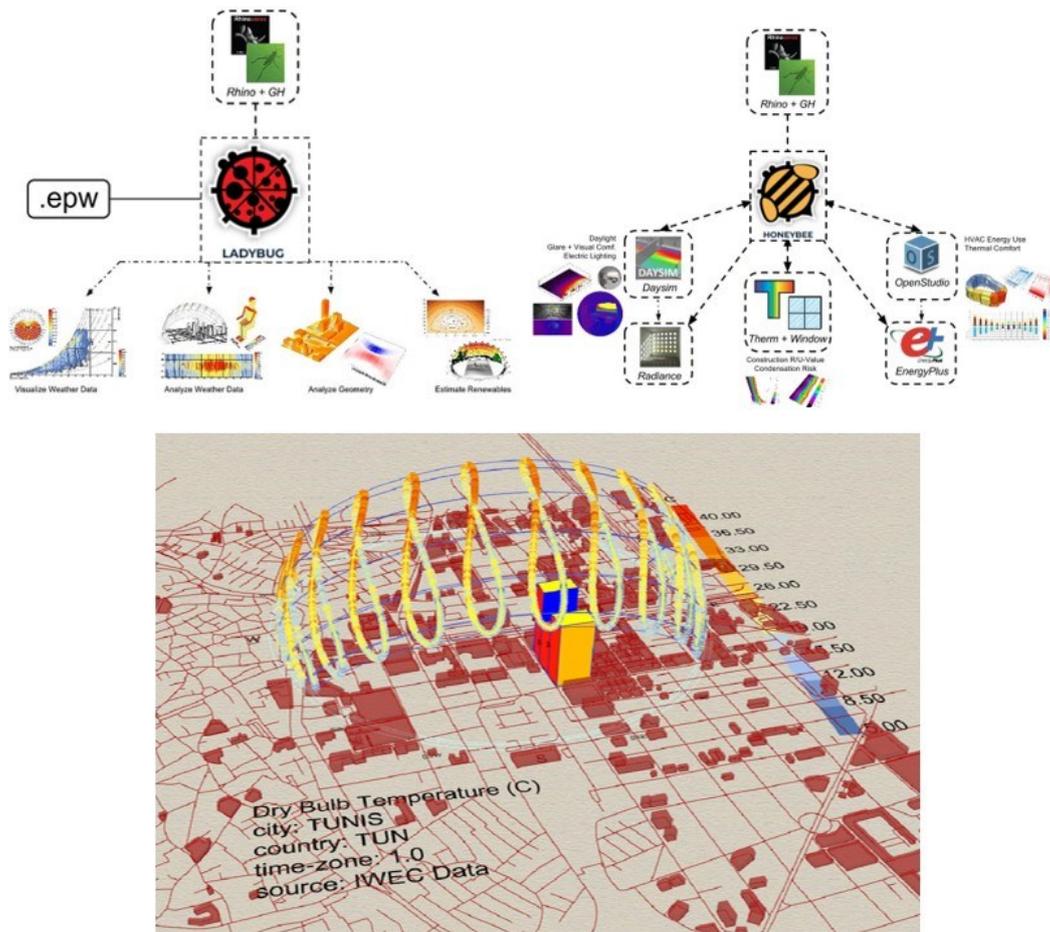


Figure 3. Climate modelisation with Ladybug and Honeybee, downtown Tunis.

### 3.1.2 Parametric Architectural CONSTRUCTIVE Design

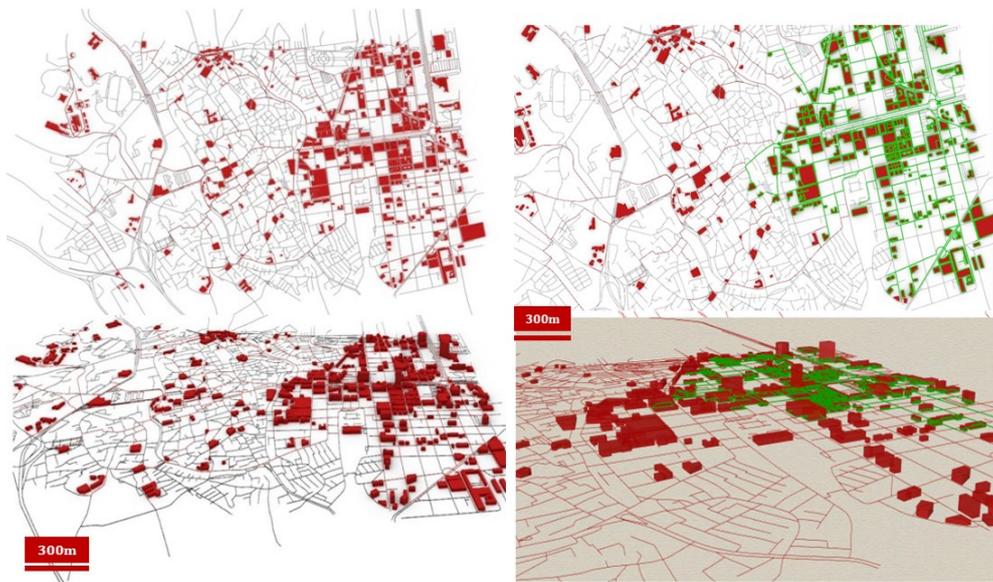
By presenting these study cases, which explain both the properties of some of the Rhino and Grasshopper programs and show examples of customized downtown Tunis simulations, we show how program and plugin management can be used to optimize and read architectural renderings. We began with the idea of a concept defined using an immaterial environment integrated into units of measure to create simulations identifying the city's atmosphere and demonstrating its capability to interact with its environment on the one hand, and with its users on the other.

Next, we became aware of algorithms supporting genomes and concordances to generate architectural models that are specific to both environmental and architectural parameters. Integrated features in Rhino and Grasshopper enable parameters to be applied to different territory components, offering great design flexibility. Grasshopper modeling enables complex geometries to be managed and shaped, facilitating the creation of innovative, customized designs. This is what the authors Domenica, Arianne, and Pepe (2022) have pointed out by asserting that the parameterization of the objects can be applied to different elements of the territory by means of the tools implemented in Rhino and Grasshopper. Indeed, programming in Grasshopper makes it possible to manage and model even complex geometries (Domenica, Arianna, & PEPE, 2022).

**Table 3.** Urbano and Galapagos as two examples of Parametric Architectural CONSTRUCTIVE Design.

<i>Typical program application</i>		<i>Interoperability with genomes</i>
<p><i>Urbano: To explore the city's geospatially in 2D and 3D, Data is collected from the OSM website. As soon as the model is downloaded from the platform, it becomes usable in the Rhinoceros/Grasshopper. (Figure 4)</i></p>		<p><i>Galapagos: Galapagos provides a prospecting genome to achieve fitness that can be maximized or minimized. Galapagos <b>minimizing and maximizing</b> mass-addition distances between the searched best point and all amenities prospected on the map as shown on (Figure 5)</i></p>

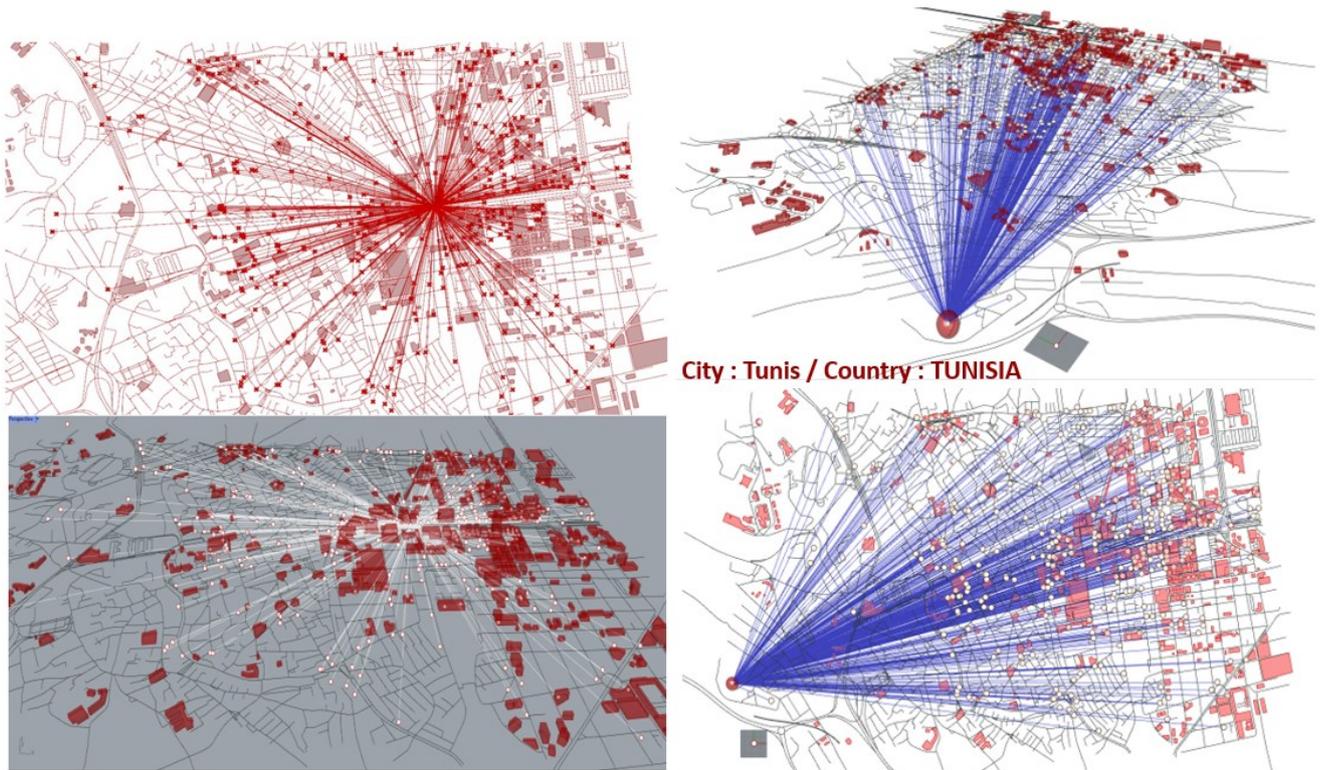
Starting from an immaterial conceptual vision and interoperating with constructive properties, the city takes shape and form, not only according to its environment and atmosphere but also according to a communal imaginary and social DNA. The interoperability of model generation makes it possible to develop a coexistence between architectural experience and perception. Digital simulations can be used to convert quantitative building structure data into more qualitative and sensorial experiences, as (Yanni, 2012) confirms by explaining that computer simulations transform quantitative models of building physics into qualitative sensory experiences (Yanni, 2012). In this same context, (Oxman & Gu, 2015) defined the particularity of this type of design as generative modeling which is mentioned as a complex process involving the development and use of systems that are concerned with the emergence of forms, from relationships, norms, and generative parameters. The emerging forms are generated by preformulated processes.



**Figure 4.** Urbano. Building 3D models using Open Street Map.

Interaction is a fundamental part of this model, as it enables generative features to be applied to design. For this, it is important to have an interactive design module that enables the designer to manipulate and direct the production of the desired solutions. In short, the generative model is a powerful tool for designers seeking to create complex, innovative forms using pre-established processes and close interaction with the system. (Table 3), highlights the interoperability of the urban cartography of the city of Tunis with the landmarks constructed in the city according to the activities of citizens. This duality is further illustrated in (Figure 5), where the Urbano and Galapagos tools resize the city according to its geographic features and the location of amenities, allowing more accurate visualizations to be designed for obvious constructions. This approach provides a better understanding

of citizens' needs and habits and can help design more appropriate and sustainable urban projects for the city.



**Figure 5.** Novel Constructive benchmarks based on distances to commodities.

The generative model is the design of, and interaction with, complex mechanisms that deal with the emergence of forms deriving from generative rules, relations, and principles. Shapes and forms are a result of pre-formulated generative processes. Interaction is a major priority in this model. To employ generative techniques in design, there is a need for an interactive module that provides control and choices for the designer to guide the selection of desired solutions (Oxman & Gu, 2015).

We deduce that parametric architectural design is a reliable [incorporating error correction] and iterative process, [Choose -select- optimize- perform-evaluate] that enhances the results' visibility and connects the user to his future environment through space prototyping. Parameterization increases the complexity of both designer tasks and interface as designers must model not only the artifact being designed but a conceptual structure that guides variation. Parametric settings can have both positive and negative impacts on tasks, performance, and designers' perception of results. On the one hand, parameterization can encourage the search for more context-sensitive designs, encourage the exploration of new forms and types of form creation, reduce the time and effort required for changes and improvements, and enable a better understanding of the object's conceptual structure in the design phase. On the other hand, configuration can require additional effort, increase the complexity of local design decisions, and increase the number of elements to be taken into account when carrying out the requested tasks (Aish & Robert, 2005). To reach a culture of innovation within architectural design, the introduction of these modeling environments provides us with some sustainable perspectives that are ultimately linked to the viability of the city and its future configuration in terms of energy, ecology, and the use of bio-based and even recycled composite materials. In the following section of our research, we will focus on the effects of such parametric models on the creation of a city's identity.

#### **4. Findings: The city's identity, from medium to object**

In the beginning, was the city. Or rather, the dream of a city. That's all. [...]. To this we've added poetry: The city palpitates like a heart, the city flies like a breath. An ever-expanding vivacity fills these imaginary cities. Some have mistaken this urban poetry for utopia (Lassave, 1992). This is how

Lassave describes the city, by attributing a connotation linked to a collective imagination. An image that refers to the city's history, inscribed in the memory of its residents, it remains alive by its belonging. This same city today takes care to satisfy the needs of all its users, a modern city, a city of consumption that offers paths, wayfinding, and especially shelter. If we decide to build a sustainable city with historical and cultural values, it should be the city that offers all the amenities needed to lead a comfortable life. A city designed according to the needs of its citizens. The visual appearance of a city is not necessarily perceived in the same way by all those who live in it, approach it, or pass through it; (Figure 6) the mental image they have of it may be forged by different feelings or practical needs: the need to find one's way around, a zest for life, aesthetic imperatives, the desire to belong to a community, etc (Lynch, 1984).



**Figure 6.** Identity is at the heart of the city's parameters.

#### **4.1 The city identity, a material, and an immaterial construction**

The city is a physically and spatially complex entity, combining economic, social, cultural, and environmental aspects. For this reason, urban design is a disciplinary field that links architecture and spatial planning. It is also a meeting hub for designers, engineers, artists, architects, and garden planners, all working together to satisfy human needs and expectations. In describing our results, we refer to two urban design pioneers and theorists, Ildefons Cerdà (Cerdà, 2022), the engineer, and Camillo Sitte, (Sitte & Stewart, 2013) the architect, who proposed two styles of discourse and two types of graphic representation, revolving respectively "The city as an object" on the one hand, and "The city as a medium" on the other. We thus propose to link together the two parametric design environments that we have pre-configured in (Table 1), as follows: a "city as a medium" that identifies itself through lived experience and the image of the drawn city, and an "object city" that builds a relationship with urban space. A constructive vision that defines typology, density, contours, appearance, shapes, and architectural functionalities.

**Table 4.** Design the city object by perceiving the environment.

Designing The Medium City. [Table 2]		Building The Object City. [Table 3]
<ul style="list-style-type: none"> <li>• Nature, history, culture, society, heritage, the idea of the city through time, the city of the future, the social imagination</li> <li>• The management of accessibility, wayfinding, behaviours, citizenship, participation, comfort, and livability.</li> <li>• The idea of a sustainable city, green design...etc.</li> <li>• Algorithm Thinking</li> </ul>	 <p>PARAMETRIC ARCHITECTURAL EXPERIENCE</p>	<ul style="list-style-type: none"> <li>• Solidity, convenience, and beauty (Alain, 1999)</li> <li>• Typology study</li> <li>• Composition modeling</li> <li>• Measuring the density of occupation</li> <li>• Urban exploitation</li> <li>• Landscape integration</li> <li>• Green architecture...etc.</li> <li>• Building Thinking- Co-conception</li> <li>• Desired, Design-outcomes</li> </ul>
<b>Connected Society</b>	<b>Connector User</b>	<b>Connected City</b>

Our research findings have enabled us to identify the crucial role of parametric modeling as a design process in the creation of viable, sustainable, and versatile spaces. Indeed, our survey revealed that the use of parametric modeling enables us to generate designs that are better adapted to the specific needs of users while considering environmental and economic constraints. This design approach also enables better integration of the various disciplines involved in the design process, such as architecture, engineering, and construction. In short, our research has shown that the use of parametric modeling can make a significant contribution to the creation of high-quality spaces that meet users' needs while being sustainable and versatile. We thus identify two ideas of the city's sustainability, the first considers that integrating parametric models to design sustainable cities is one of the major solutions for rebuilding and reclaiming a viable space, which is defined as a geographical entity unaffected by economic or other factors. The new concept of sustainability must have the first name “urban”, so that, when we talk about urban sustainability, we will be talking about spatialized sustainability, not a concept that belongs to ecology, economy, or sociology (Ferial, Kitouni, & Sassi Boudemagh, 2018). The second is considered an evolutionary process that takes environmental well-being into account. Sustainable urban development may be defined as a process of synergetic integration and co-evolution among the great subsystems making up a city (economic, social, physical, and environmental), which guarantees the local population an on-decreasing level of well-being in the long term, without compromising the possibilities of development of surrounding areas and contributing by this towards reducing the harmful effects of development on the biosphere (Camagni, 1998). We would also add to this the human factor in the composition of the city: a viable, sustainable, and versatile city relies on the citizenship of its people, and above all on their participation, (Table 4). The city's actors are simply its users. The phenomenon of participation has been an essential component of the globally accepted sustainable city concept since the 1970s. (Turken & Eyuboglu, 2021).

**4.2 Discussion: Planning and inventing the city's future, users at the heart of Design Process**

The following discussion constitutes both a model, an outline, and a proposed call to action for thoughtful research and applications in parametric design architecture. Indeed, our in-depth analysis has highlighted the importance of using parametric modeling as a design tool for creating innovative and sustainable spaces. We are convinced that this approach can bring real added value to current architectural practice, enabling designs that are more precise, more efficient, and better adapted to users' needs. This is why we are calling for concerted action to encourage research and applications of parametric design in architecture. As classified through (Table 4), we are convinced that this approach can help address some of the most pressing challenges facing our society in terms of sustainability, energy efficiency, and adaptability to environmental change. We therefore encourage architects,



engineers, urban planners, and researchers to explore the possibilities offered by parametric modeling and to work together to develop innovative, sustainable solutions for urban spaces and buildings. In short, our discussion is a call to action for more widespread use of parametric design in architecture, in order to meet the challenges of our time and create a more sustainable, user-friendly future. We want to highlight the necessity of co-designing the city and establishing a new culture of interaction and participation. The right to the city involves two fundamental rights for urban inhabitants: the right to oeuvre (participation) and the right to appropriation (Zeybekoglu, 2022). A culture that reconfigures the city in digital, parametric, and essentially human terms. To satisfy a future space user, parameter synchronization is defined and based on specific needs. The parametric design of architectural environments is based on this concept, using tools and programs to present a model close to reality and to convince consumers of the viability of the space concerned. The parametric design of a spatial configuration considers the usability of both spatial modeling as a prototype and the city itself as an environment and a concrete design context. Architectural space modeling thereby has a dualistic function: one centered on the spatial experience as a model, and another centered on the user experience as a participant. This new architectural space representation and spatial prototyping technique offers an experience that is characterized by the three classic "Ux" factors: system, user, and context. In conjunction with (Fink & Reinhard, 2019) ideas, they suggest that cultural aspects can be incorporated into the design process by involving citizens. Participation platforms, tools, or applications can be developed and integrated into this process to meet citizens' needs. By involving citizens in the design process, professionals can better understand the needs and expectations of the local community, which can contribute to the creation of more suitable and sustainable spaces. Participation platforms can take different forms, such as surveys, focus groups, participatory design workshops, or collaborative mapping tools. These tools enable citizens to share their ideas, concerns, and needs regarding public spaces and buildings, which can help designers create more suitable and effective solutions. In short, this idea suggests that involving citizens in the design process can help create more sustainable spaces that are better adapted to local needs. Cultural aspects can be considered through the involvement of citizens. Participation platforms, tools, or applications can be developed and incorporated into this process to address and screen citizens' needs. It can be concluded that the application of digital tools within the urban planning process is state of the art, in business and research. Towards an efficient workflow in the future, open-source tools will be considered as a driving force to support the research. The collaboration between different institutions and the sharing of knowledge is critical to strive for better solutions (Fink & Reinhard, 2019).

To further develop the discussion around our research we propose future readings that can optimize and revalue parametric design models. Thus, we mention in the following points the fundamental aspects that need to be taken into consideration:

- Exploration of new forms of parametric modeling for architectural design, such as AI-based or generative modeling, which enable greater flexibility and adaptability to user needs.
- In-depth study of the impact of parametric design on the sustainability of buildings and public spaces, examining energy, environmental, and social aspects in particular.
- Development of new citizen participation tools for parametric design, such as mobile applications or online participation platforms, enabling users to actively contribute to the design process.
- Benchmarking the performance of buildings designed with the parametric method against buildings designed with traditional methods, to establish the advantages and limitations of this approach.
- Study of the economic feasibility of parametric design for architectural projects, examining the costs associated with the use of advanced technologies and the involvement of users in the design process.
- Exploring the use of parametric design to create more inclusive and accessible public spaces, considering the needs of disabled and elderly people.



- Studying the impact of parametric design on the health and well-being of users, examining aspects such as daylighting, air quality, and acoustics.

In sum, these prospects for future research can help improve our understanding of the use of parametric design in architectural construction and offer users new opportunities to connect with their immediate environment.

## 5. Conclusions

This research presents an innovative approach to the architectural design of the city using parametric context as a new paradigm for creation and conceptualization. This approach enables designers and spatial researchers to conceive, plan, and implement changes in the world around us while considering citizens as the main actors in their living environment. Digital modeling is an act of creation that humanizes time through the act of creating, modeling, prototyping, and configuring. This experience suggests that designers and consumers of space should open up to a new culture of designing architectural projects, based on human methods and ways of thinking.

City design strategy must be citizen-centric, it is necessary to recognize that including participatory aspects in the architectural design requires, to some extent, a greater effort than with the authoritarian model (Giuseppe, 2021). By considering the city's history, identity, and sustainability, designers can create a city that reflects the values and culture of its inhabitants. Using parametric design, architects can create buildings that are both innovative and sustainable, while using energy-efficient materials. This approach can also be used to create a coherent identity for the entire city, using similar design principles and materials across multiple buildings. In conclusion, parametric design is a promising approach to architectural design for the city. Using this method, designers can create innovative, sustainable buildings that reflect the values and culture of the city and its inhabitants.

In return, it's important to point out that while parametric design can offer many benefits in terms of sustainability, energy efficiency, and architectural innovation, it can also present limitations in relation to environmental and social change. The results of parametric design can be influenced by factors such as costs, government regulations, and investor preferences. This can limit the ability of designers to create buildings that fully meet the needs of citizens and the environment. What's more, while parametric design can offer benefits in terms of energy efficiency, it can also encourage an over-reliance on automated technologies and systems. This can lead to a reduction in the interaction between people and their built environment, with potentially negative consequences for quality of life and mental health. Ultimately, parametric design must be used with care and in conjunction with other approaches to ensure that the results meet the needs of citizens while being sustainable and environmentally friendly. Designers need to be aware of the potential limitations of this approach and work to find creative solutions to overcome them. Despite these identified limitations, parametric design remains an important approach in defining a city's identity and creating a viable, sustainable space. Using this method, designers can create innovative, durable buildings that reflect the values and culture of the city and its inhabitants, while fostering positive interaction between people and their built environment.

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### Data availability statement

Data is openly available in a public repository that issues datasets with DOIs.

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