

# Parametric and algorithmic design: faux forms?



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Architecture is often practiced in a world dominated by the many, the client or the public and in many cases only understood by the few. Architecture has been relatively unsuccessful at moving forward with the world often failing to relate and communicate with cultural shifts, changing ways of life and the advancement of technology. Where other design related practices such as the automotive industry have blossomed, re seeded, re grown and regenerated with shifts in the way people live and the technology of the present, architecture seems to have floundered. As a result architects currently work in an environment employing century old technologies, with a client market which avoids risks to personal gain at all cost and a public which often still sees the present seen in architectural history as the very form of a relevant architectural future. The masses seem bewildered by the possibilities presented by the possibilities of the present. Even fellow practitioners and academics within the architectural discipline would appear to be slightly taken aback by the possibilities now available to us. Not just on a technological level, but the impact that these new techniques may have on the very basics of architectural theory and form. This brings me to my question... .. Parametric and Algorithmic Design: Faux Forms or a Relevant Architecture?

Computer aided design changed many design orientated professions such as the automotive and aeronautical industries as far back as the 1980's when they were first properly developed. A digital revolution if you will. Compare this to architecture where production and design still use techniques, theory and knowledge developed during the industrial revolution. Although the majority, if not all architects do use some form of computer aided design

techniques the boundaries can still be pushed further. Processes such as BIM (building information modelling) are starting to become a real force in architectural design in places such as the USA. BIM is a process where the architect does not simply draw a line as with traditional drawing techniques or with programs such as AutoCAD (which to an extent, is simply a digital version of a traditional drawing) but instead when an architect draws a line, he draws a wall, with the possibility to combine this information with a limitless selection of properties be they size, cost, structural or how they relate to other members in a design. BIM begins to hand back the title of “Master Craftsman” to the architect, where the architect can see how design develops as a whole and make changes accordingly. Parametric and algorithmic architectures are currently at the forefront of the BIM architectural thinking, they are the products of the few created using advanced computer scripting techniques and individually written pieces of software. Using the latest design technologies available to us, combining this with the modern materials and production techniques often developed in fields which have embraced the digital revolution more openly, parametric and algorithmic design can begin to challenge cultural, technological and historical boundaries which architects have maybe failed to fully challenge in the recent past.

Parametric design is a process based not n fixed metric quantities such as traditional design but instead, based a consistent network of relationships between individual objects, the bricks are different but they are connected with the same bond. This allows changes to a single element whilst working with other components within a system.

In a similar way to that of parametric design, developments in scripting have allowed for algorithmic design processes to advance. These allow complex forms to be grown from simple methods while preserving specific qualities. In the most basic sense, a user defines a set of rules, and the software would arrange the form according to the rules.

If parametric design is a method for control and manipulation of design elements within a network of any scale, algorithmic design is a system and objects producing complex form based on simple component rules. With the combination of these methods, principles, modern production techniques and materials parametric and algorithmic architectures have the potential to push architecture, beyond doubt into the 21st century.

Age old architectural problems and theory such as “ form vs. material” and “ form vs. function” can begin to be solved in new ways, construction times can be reduced, materials can be managed more efficiently, and building qualities can be improved significantly. In the analysis and comparison of two projects utilising parametric and algorithmic architectural design principles, I aim to fully understand how relevant these forms and methods of producing architecture really are when compared to their traditional counterparts. I have selected my examples from opposite ends of the architectural scale size wise, but from a similar family of traditional public architectural type form, analysing how relevant the parametric forms are in relation to different situations and settings.

My first investigation, looks at a temporary theatre located within the site of Corbusier’s Carpenter Centre - A collaboration between architecture Firm

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MOS studios and artist Pierre Huyghe, selected for its truly unique location and it's contemporary play on the more traditional theatre / pavilion / bandstand form. Theatres are traditionally very grand buildings, for thousands of years they have been part of human culture with forms as far back as ancient Greece still found in theatre design. This coupled with its band stand / park pavilion like size associated with formal pavilions form around the Victorian age made the project particularly interesting. The challenge for MOS studios was to produce a take on the theatre whilst reacting appropriately to its location in what is an extremely prominent place.

The design in basic form is similar to that of any regular theatre with raked seating, unhindered viewing and high-quality acoustics but it was with the use of parametric processes that a theatre which corresponds to the individual conditions of the site has been produced. The theatre sits in the underbelly of the Carpenter Centre by Le Corbusier, commissioned to commemorate the 40th anniversary of the building. Corbusier's Carpenter centre is the centre for the visual arts at Harvard University, MA. Completed in 1942 the building is the only building ever completed by Corbusier in the United States of America and the last to be completed during his life time although he never actually visited the building due to ill health. The building corresponds with Corbusier's five points of architecture (as seen in the Villa Savoye, France) with interior elements such as the ramp, a dominant feature, exploding out from the inside of the building providing an s - shaped walkway continuing into the environment. Curved partitions also extend through the main walls of the building in to the surrounding areas swinging

to and from the pilotis which support them. This creates a series of interpenetrating interior and exterior events running along the promenade ramp. Within the design of the Carpenter Centre you can see the elements of projects spanning the entire career of Corbusier modified and adapted into this building.

The puppet theatre itself, like Corbusier's Carpenter Centre, was designed with a set of parameters or architectural rules if will. These parameters were derived from a given brief and limitations of the space created by the Carpenter centre itself. To avoid damaging the Carpenter Centre no contact with either the ceiling or the buildings supporting structural systems was permitted. Therefore, fitting the puppet theatre in between these important structural barriers became key. The architect has described the theatre as "an organ placed in a new host", it has a feel similar but not exactly that of a parasitic structure. It seems not to be taking away, leaching from the Carpenter, but adding to it, giving it new life as though it really is a new organ, a new heart. This imagery is reinforced in the choice of materials for the theatre, further expressing the feel of new life. The main self supporting structure is a polycarbonate, clad on the outside with a moss. The moss adds heat and noise insulation, absorbing sound from the nearby street with sound quality being of paramount importance in practicality of a working theatre. At night light from within the theatre glows through the light polycarbonate & moss giving a green glow, as if it really is a new organ, a new hub from which life stems into the Carpenter Centre.

The rounded form of the theatre was produced through the parametric manipulation of elongated diamond shaped panel units, each one individual

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in form, each one connected through the same set of parameters. This parametric manipulation was created through the limitations of site, the need for self supporting structural integrity, the use and the restrictions of fabrication processes during production. The ultimate form is therefore created through a system of analysis where the most efficient form was deduced using the parametric system. Most of the theatre was prefabricated and assembled off site. The elongated diamonds were designed to be produced from a single flat piece of polycarbonate minimising both manufacturing times and wasted materials. Each of the 500 pieces was CAM cut, before being folded into three dimensional forms with points drilled to connect each of the diamond forms. The entire structure could then be assembled by connecting the panels using simple tools. The use of simple hand tools meant that the theatre could rapidly be assembled and disassembled, suitable to the temporary nature of the structure, it was imperative that the structure could not only be disassembled, but left no permanent trace of its construction on the carpenter centre. This again was made possible through the use of parametric design. Each panel is 3" in depth and spans over 15" at the centre; they were stiffened with a foam insert to help with rigidity with the combination of strategic panels being placed inside out, thus acting as key stones. These strategic inside out keystone panels also act as skylights, allowing light to travel both in to and out of the theatre. When assembled the panels dissipate forces around the skin of the theatre, creating the self supporting monocoque structure. The monocoque structure mean that no permanent fixings or structural supports had to be made with the Carpenter Centre, therefore the puppet theatre

became connected through its relevance as a design but remained separate as a structural object.

With the puppet theatre sitting in a sunken exterior courtyard underneath the Carpenter Centre, the change in level of 1.25m between the street side and the courtyard had to be addressed, and so this became one of the key parameters in the design. This was overcome by incorporating the 1.25m change in level into the raked theatre seating, with the actual performance stage sitting at the lower level of the courtyard. As you enter the puppet theatre at street level, the elongated diamond forms combine with the change in height and almost surreal sizing of the puppet theatre itself to creating a visual illusion, a false perspective. This invites the visitor into the theatre with a sense of magic and curiosity, drawing the eyes towards the stage end where the parametric boundary lines of the diamond forms stop abruptly with the introduction of the stage. The use of this optical illusion helps to reinforce the sense of theatre, a sense of magic that I feel could be easily have been missed or overlooked with the use of other materials or construction techniques. You could maybe say that similar forms could have been created in concrete or wood, but then the all important play of light created by the polycarbonate panels chosen would have been missed. With the combination of material and parametric design "theatre" is actually incorporated into the design of the structure.

The Glossy polycarbonate panels also reflect light, creating an ambient glowing light during performances, with the only lighting coming from the puppet show itself, this transforms the theatre into a glowing lantern at night, projecting its energy onto the bare barren concrete surfaces of the

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Carpenter Centre. It seems to work well in a juxtaposition between the high-tech nature of the design and the connection created with what is a very ancient form of entertainment, connected by lighting which would seem to draw you in a similar way to that of a candle light. During the day the reflectance is reversed when the natural light brings the exterior surroundings into the puppet theatre, this focuses the attention on what is happening in the outside world, the walls almost become the walls of an aboriginal cave, telling the stories of the exterior world as they are happening. This connection to the outside world through the reflectance of light is reinforced by the framing of a single tree which sits beyond the entrance of the theatre. It frames the view with some purpose whilst creating a sense that the tree could possibly act as some barrier, a limit to the boundary of the theatre's threshold.

Through extensive analysis and research this theatre and its host building, the Carpenter Centre I believe that this truly is a remarkable form, an excellent piece of design. The theatre works with and answers to every one of its parametric challenges. Through the use of parametric design I feel that a form has been created that would otherwise never have been imagined or realised. The organic form of the theatre, created using very non organic production techniques answers to the brief on so many levels. It creates this new heart, new hub for the Carpenter Centre. It does not try and mimic the great modernist architecture used by Corbusier himself, but in no regard does it fight against it, it somehow moves in to an architecture beyond, with each individual member of the theatre being very geometric, but arranged in an intelligent way, produce a form which is more organic. Neither structures

the same but they do work together. The puppet theatre design speaks of the Carpenter centre today; it speaks not of the architecture and the Carpenter Centre of the past, but the architecture, the people and the Carpenter Centre of the future. The architects could have chosen so many different approaches to producing a pavilion of sort on this site but I'm positive they would have struggled to produce a design that overall worked more responsively with the entirety of the design challenge presented.

The second example of parametric architecture that I have analysed is the Mercedes Benz Museum, Un Studio, Stuttgart 2005 - with parametric and algorithmic working by Designtoproduction. This example of parametric design was selected not for its obviously parametric appearance but for the way in which parametric modelling combined with BIM was used in the construction and design of what can only be seen as a truly revolutionary building. Today the majority of the worlds exceptional historical, cultural and artistic pieces of are all in place, the future of the museum, as seen with this, the Mercedes Benz museum, lies with those who can fully communicate a specialist collection, what they are about and where they came from. They have the capability to stimulate a culture much more than a generalist collection, the works, the cars in the museum could be seen to speak much more of the people that the majority of today's art. This is where the use of parametric design can be seen to influence and completely communicate the work of Mercedes in a new way. The importance of museum design has been at the forefront of architectural thinking since Frank Lloyd Wright first challenged the plan of the museum with the design of the Solomon R. Guggenheim Museum in New York, 1969. Since then museum has been

challenged again and again by a multitude of architects such as Renzo Piano & Richard Rogers with The Pompidou Centre, Paris, 1977 and Daniel Libeskind with the Jewish Museum, Berlin, opened 2001. The Mercedes Benz Museum can be seen to relate to all of these examples in its pursuit to step forward away from the regular, to challenge the spaces, circulation paths and forms of a museum, to create a museum of purpose. The success of a museum depends upon the inventiveness of its internal arrangement, spaces created and its ability to exhibit artefacts within these spaces in a relevant way. The museum will / has become famous not only in the continuing line of challenging museum architecture starting with buildings such as Frank Lloyd Wright's Guggenheim in New York but for putting the digital design process firmly on the map.

Stuttgart is home of the Mercedes Benz brand, and so with the need of a new museum, UN studios were chosen to redesign a new museum on a new site close to the main gateway to the city, where the old museum had previously been located in a dedicated building within the actual Mercedes factory. The design is based on a concept involving the over laying of three circular forms in plan with the removal of the central space creating a triangular shaped building height atrium area. In section the building raises over eight floors in a double helix form, maximising space and providing 16, 500 square meters of useable space on a relatively small footprint. Originally the brief brought to UN studio suggested that the building should be no more than two storeys high with worries that any more height in the building may cause complications with exhibits, for example the manoeuvring and exhibiting of lorries, circulation problems around such large pieces and structural integrity

of the building with extremely heavy exhibit loads. With the site being situated so close to a major motorway it was soon suggested by UN studios that the building should be taller relating to the close situation to the motorway, seeing that problems such as circulation and weight of exhibits could be overcome with the correct knowledge and attitude towards the project. The circulation system used in the Mercedes Benz Museum is similar to that used in the Pompidou Centre Paris, with the circulation running around the external facade of the building. In a similar way, the circulation can be seen to draw clear links with the ramp-like circulation of the Guggenheim New York. The main difference with both of these buildings is that the Mercedes Benz museum has, through advanced construction techniques combined with the use of parametric modelling, is able to convey the main forces applied to the building to a structural core through floor slabs rather than perimeter, therefore fully liberating the facade and plan of the building.

The visitor enters the building on the ground floor where they are met by the vast scale of the open atrium. This ground floor is home to the general facilities expected of a large museum; reception, gift shop and cafe but it is where the tour begins that the form really takes a leap forward. The museum is designed so the visitor is transported to the eighth and top floor of the building before working their way down double helix form ramps on a tour that would take approximately six hours to complete in entirety.

Transportation to the top floor is a celebration in movement itself, the visitor is transported via a portal-like elevator with limited viewing; "flashes" of projected imagery are seen from the inside. Once at the top floor, two tours

split from the starting location each following one of the double helix ramps, each following a different side to Mercedes vast history. The two tours known as “ Collection” and “ Myth” vary in their exhibits with the “ Collection” tour being more of a historic timeline of Mercedes design and the “ Myth” tour taking more romantic, cultural take on Mercedes history, featuring some of the company’s greatest designs and cars previously owned by the likes of Ringo Starr. As a result the special feel of the two tours has been designed to vary and adapt to the various exhibitions enormously. The “ Collection” tour is flooded with natural, truthful lighting whilst the “ Myth” tour is illuminated in a much more theatrical way, mimicking the romance and glory associated with its exhibits. The tour paths do cross at various points through the vertical of the space, allowing the visitor to pick and choose between the two tours.

The eight levels of the building are separated into regular and special areas, based on their functions within the museum and their impact of the structure as a whole. The levels alternate between single and double height spaces as they progress through the vertical of the building. Classical sculptors such as Bernini and Brancusi knew the importance of the pedestal, they were masters of this, once again the pedestal has been utilized in this museum, creating views, highlighting without blinding and focusing the visitor’s attention where it is needed. Not only have plinths been used but with the employment of the semi circular ramps which hug the exterior boundaries of the building, perspectives have been produced, providing new, interesting and invigorating views of the exhibitions. Viewing the leaf shaped, semi circular, exhibition spaces from a multitude of heights as you descend

through the building generates a series of panoramic overviews. Visitors see the exhibits from higher, lower, closer and more distant view points. No viewing angle is ever quite the same, and the normal head on viewed approach is avoided, there is a sense that you will never capture every view throughout the tour, that the building is constantly changing, twisting around and beyond you, that you as the visitor never quite fully understand where you are within the building. Together the pedestal, panoramic viewing spaces and constantly twisting forms create a new special complexity within the form of a museum. Never before has something been exhibited like this before. There is a constant feel of movement within the exhibits and the form of the building. The museum “ tries to set the static in motion” says one German architectural critic, “ as if it wants to prove that the architecture is still alive”, it has been said to explore motion in all of its possible expressions. The whole acts as an accelerator for the different, unpredictable and sometime incomprehensible spaces presented to the visitor.

The open plan has been achieved through the ability to transmit vertical loads to the central distribution cores via the floor slabs with the facade systems carrying limited vertical loading. The floor slabs within the exhibition areas cover an area of almost 30m without intermediate structural columns, made possible through the use of parametric modelling and advanced structural calculation. In addition to the actual exhibit weights and live loads such as visitors to the museum the floor slabs also have to transfer a significant amount of the horizontal load from the twisted exterior structural system to the huge central tri column core of the building.

The floors slight curvature and incline help to create a truly dynamic space around the cars aswell as creating the structural support for the building. The floor folds, becomes the wall before folding again to become the ceiling. UN studios most recent works have been described as relating to and recalling ways in which baroque architects worked and diagrammed their work. Van Berkel, co founder of UN studio, amused by the comparison says" I have been really fascinated by Bernini and Borromini. Not just in their buildings but by their incredible ability to cast their discipline into question with innovative representation techniques". These techniques are imperative in the means of bridging the gap between the abstract of thought and the realism of building construction, they become essential when beginning to comprehend how a structure may work and how building may operate. They open new horizons and give architecture a holistic dimension, a means of creating volumes that respond directly to project requirements.

As an ultimate statement: The Mercedes Benz Museum by UN studio could not have been created without the help and research offered by Designtoproduction and their parametric work. There was limited time to design what can only be described as one of the most complicated structures in modern time, and so, over two hundred and forty six different companies and engineering firms were employed to help with the production of the Mercedes Benz Museum. Designtoproduction were able to provide solutions to the gaps between separating design and production. This was imperative as these steps are interconnected, they highly influence each other and with so many different teams working on the project, strong design and production links were needed. Parametric design proved to be the key to the

buildings success in this regard. “ The only solution was to control the geometry of the building as completely as possible using the latest computer technology” Ben van Berkel, UN Studio’s co founder and director. The intertwining forms of the Mercedes Benz Museum meant that the forms could barely be described using standard plans and sections, yet contractors needed working plans, sections and details to construct the building. From the basic geometry of 2D parametric modelling, the edges were transformed in to constantly rising 3D forms by layering levels; ultimately the 3D volumes of the structure began to rise from the layering of plans. For different building components the geometry was directly taken from the model, thus closing the chain of information from early design stages until the construction and fabrication. For example, the formwork for doubly curved surfaces was accurately developed into plain boards taken from information in the parametric model.

Designers don’t think in numbers, they think in relationships, in connections, in the whole. CAD packages do not think in relations, they think purely in numbers, they do not care for relationships or what they represent within the form or design of building. The parametric CAD models that Designtoproduction produced combined these numbers behind the developing building in a set of a parameters, dictating what would work and what would not; therefore thousands of numbers become merely a handful of meaningful parameters. The parametric model for the Mercedes Benz Museum was not only part of the design but key to the construction. It linked the participating trades in the building in a harmonic whole with the architect acting once again as the master craftsman at the helm, overseeing the



construction as a whole. Unlike those who use digital architecture merely for aesthetic qualities, UN studios have gone beyond anyone else in the means of imaginatively managing a building through a design with a mathematical parametric model, without compromising the initial design principles, cramping the design with formal or preconceived solutions. The Guardian's architecture critic Jonathan Glancy has described the building as "jet-age baroque". The use of parametric design tools, the architect had been able to design and create a building which seems as though it is a product of or closely linked with the Mercedes Benz brand. It screams movement, technology, the future, and the impossible. If you think about this building in any other sense, an exhibitor of modern art, an exhibitor of any other form of specialist collection or historical artefact it simply would not work. The building would seem to be truly purposely tailored to the client and purpose, that of exhibiting the greatest works of Mercedes Benz, with this, the museum is already seen by many as one of the single most astonishing buildings of the new century.