Gian F. J. Hartono | gg31hh@gmail.com
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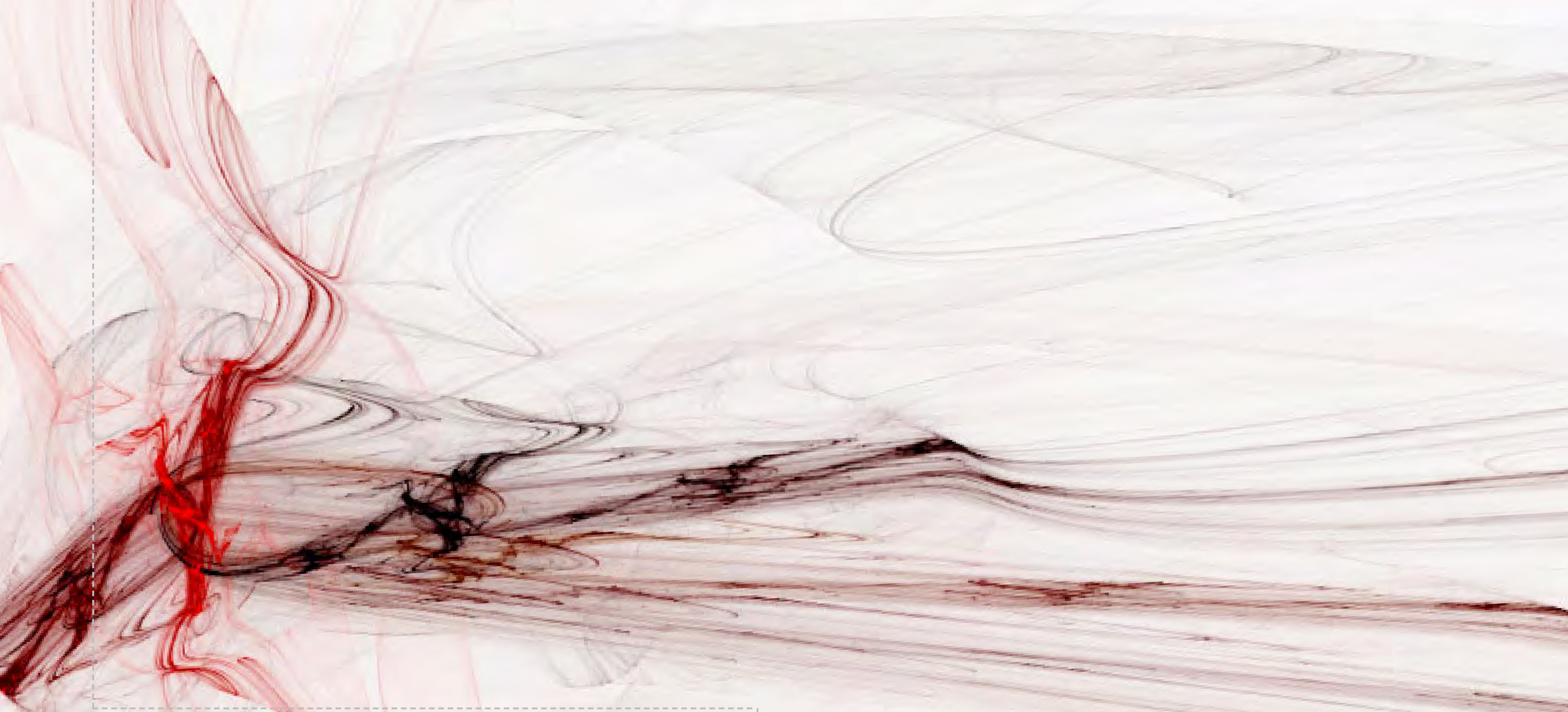
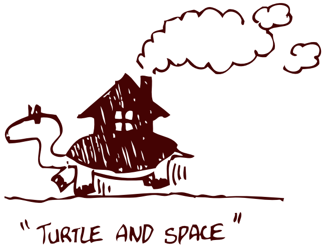


SCRIPT + ARCHITECTURE

2nd year Master of Architecture | 2010

"Master Thesis explanatory document"



"Can an algorithm-based form finding tool be used to aid the investigation of early pre-conceptual spatial design, the results of which an architect can later use as a design template ?"

ABSTRACT

The objective of this Master's thesis is to investigate the use of computer algorithms to aid the pre-conceptual stage in architectural design. The concept juggles the real world and the world of virtual design. I will be investigating various possibilities of algorithmic modelling and the impact of doing so.

My intention is to investigate the possibilities of the pre-conceptual computer algorithm as a tool, I first focus on a key study of relationships within the spatial assembly of performing arts centres (PACs). This is achieved through a case study analysis of PACs, in order to understand the parameters, which are then applied to my site (the Unitec performance theatre). By use of computer modelling tools an 'ideal' layout for spaces will be determined for the design of the Unitec theatre.

Three real-world performance art centres were investigated: The Auckland Performing Arts Centre (T.A.P.A.C), Maidment Theatre - Te Atamira, and Bruce Mason Centre. After critically evaluating how the spaces were arranged within those buildings I propose some commonality between those three centres. This forms the "essence" of the programming script that is later created.

As a control for the effectiveness of the script, I used real world T.A.P.A.C data and collected the results produced by the script. This way, I can judge whether the script model I created is valid

Having successfully confirmed the results to be similar for both the real-world and virtual T.A.P.A.C, the written script can be accepted as a valid tool. I therefore used the tools in my proposed design project for the Unitec theatre. The results offered a number of different possibilities. These possibilities provided a wide range of unexpected arrangements. It was then necessary to judge and critically filter the results

This experiment has been proven to work as each space has its own hierarchy in relation to its individual site. Computer programming also proved to be very fast and flexible to moderate the model as a pattern of data. Possibilities of widening the vision of an architect by providing a number of valid solutions which may later be used as a design template during the architect's pre-conceptual stage have also been found to be useful.

This project shows how to not only successfully investigate the possibilities for the use of aided computer's algorithm in architecture design, but also proposes a new parallel line of design process from which architects can benefit. This is a promising field within the architecture-digital research topic, as it suggests how the developed models may be further enriched and states the current limitations to the script, which could be developed further.

Contents

Acknowledgement

It is my pleasure to thank all those who have made this thesis possible. An extended thank-you should be sent to David Rhodes, Peter McPherson, and Nikolay Popov for their help throughout the year, as well as Professor Mike Austin and Brendan Smith who have generously assisted me with the written document.

Finally, I would like to thank all of those who have supported me at Unitec, both my colleagues and tutors who have been invaluable during the completion of the project. A special thanks to theatre-director Paul Minifie of the Maidment Theatre Centre from the University of Auckland for patiently guiding me.

Introduction

General overview

"Can an algorithm-based form finding tool be used to aid the investigation of early pre-conceptual spatial design, the results of which an architect can later use as a design template ?"

Aim

Optimising the initial spatial layout within the pre-conceptual design stage of a Performance Art Centre (PAC) within Unitec Campus by using contemporary spatial arrangement computer software tools.

Objective

- To focus on the key study of relationship within the spatial assembly of PAC spaces.
- To begin to understand the logic behind computer programming (scripting) and how it can be beneficial within an architectural design process.
- To investigate the possibility of widening the architect's vision by giving him several valid spatial arrangement templates, from which he may later may choose best fit using his subjective judgement.
- To research into popular Auckland Performance Art Centres and analyse how a PAC's spaces are arranged and converted into useful data.
- To analyse in order to establish a pattern of data from case studies which may later become useful due to the series of algorithmic model technique.
- To test the model on the existing T.A.P.A.C site with reference to the data collected from the script.
- To create a useful model on the Unitec PAC.
- To develop a theory behind my concepts to enhance further algorithmic architecture research
- To take the final result to the industry user.

Outline of the Project

"Space as an architectural theme has been explored in many ways over many centuries; designing the architectural space is a major issue in both architectural education and in the design process. Based on these observations, it follows that computer tools should be available that help architects manipulate and explore space and spatial configurations directly and interactively." [1]

From the outset of the project, the first major question is – *"Is there a way to write an Algorithm / script which allows the computer to be more creative and understand the ideal architectural concept within a given site?*

Due to the lack of rational free form thinking of a computer, it has no ability to judge the subjectivity of spatial arrangement the way a human can. Methods do exist, if one provides a set of rules, which could guide the computer in generating simpler simulated models to allow architects to further build on. However, one of the methods which gives flexibility and does not generate fixed results is the *bottom-up simulation*[2] which creates unexpected and profound results.

In the world of design, computer programmes have taken over many human intellectual tasks. From Photoshop filters to virtual modelling applications, simulation programmes to virtual reality animation, and skilled tasks such as rendering, paper cutting, mapping, 3D sculpting or modelling (3D Printing), they have left fewer tasks for traditional designers.

During the mid- 1990s, some practitioners began setting aside traditional methods of computer-aided design systems to experiment with the more cutting-edge 3D modelling programmes used for special effects in films and animations. Critic Reed Kroloof entitled it, "blobitecture"[3]. Sculptured architecture, such as blobitecture, is made possible with the help of today's software programmes. Not only can computers simulate organic structures, but also calcu-

1 D Kurmann, N Elte, and M Engeli, *"Real-Time Modeling with Architectural Space"* (Kluwer Academic, Dordrecht, The Netherlands; 1997), 809 - 10.

2 P Coates et al., *"The Use of Cellular Automata to Explore Bottom up Architectonic Rules"* (Eurographics UK Chapter 14th Annual Conference, 26-28; March 1996 London: Eurographics Association UK; 1996), 1 -3.

3 John K. Waters, *Blobitecture : Waveform Architecture and Digital Design* (Gloucester, Mass.: Rockport Publishers, 2003), 8 -12.

The Frank Gehry's Guggenheim Museum in Bilbao, Spain

The Frank Gehry's Guggenheim Museum in Bilbao, Spain

late the amount of sound or light bounced within any given space. Such examples include Frank Gehry's Guggenheim Museum in Bilbao, Spain

I have tried to design blobitecture in past projects which I have found challenging regarding the level of harmony between the required functional spaces and the interesting internal spaces created from expressive façades. Eventually I came to realise that the limitation of a computer does not stop it from generating an architectural form. Nevertheless, could it also generate spatial arrangements?

"Algorithmic scripting techniques involve the articulation of a strategy for solving problems whose target is known, as well as to address problems whose target cannot be defined. Within the realm of computer graphics, solutions can be built for almost any problem regardless of its complexity, amount, or types of work." [4]

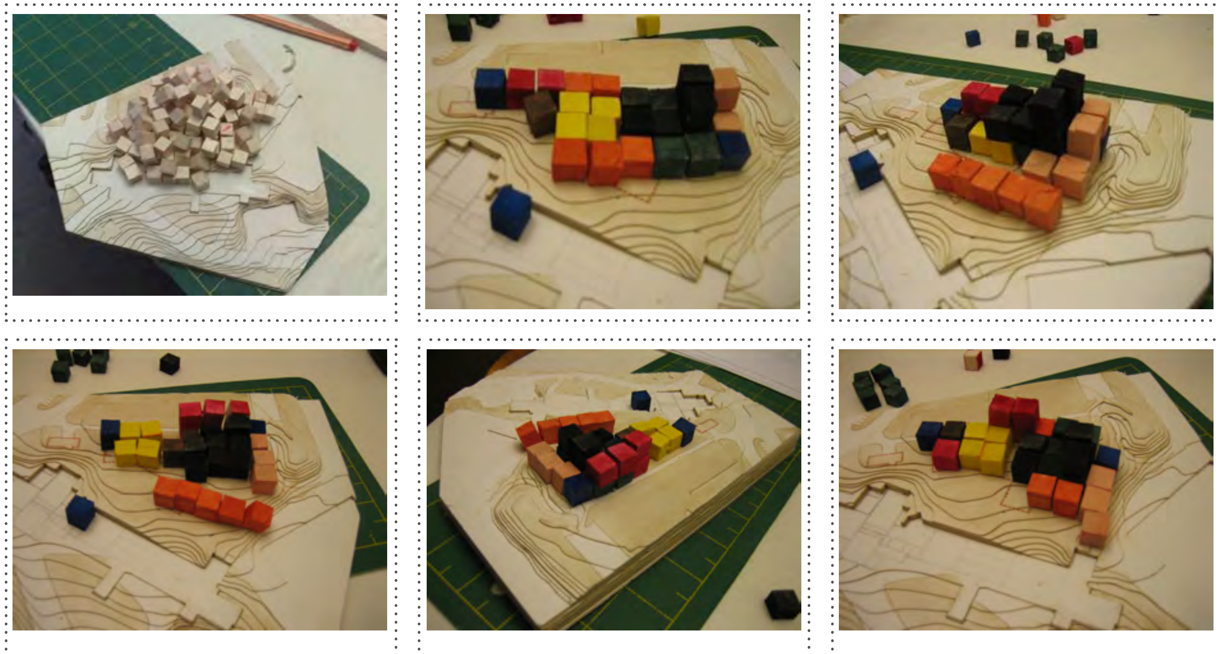
Imagine if we could visually understand the spatial arrangements of possible form from an architectural programme as it is constantly updated. This could give the architect full control and awareness in both form finding and the required internal spatial design. By defining the problem, the architect could find a strategy that organises compromises within the spaces created and the exterior expressive form.

It is not my suggestion that one should follow the outcome given by the computer, but rather a template from which the architect can experiment and realise the effect of programming on the internal arrangement. This not only aids with the creation of new sculptural forms with a more mature understanding of space, but also provides a tool for the architect to study and experiment with.

This dilemma comes back to a non-related thesis question: the classic debate of whether the form or the function should come as priority. In this case, the function of a building becomes the most vital part of the design question as one could study how an algorithm model may help within the design processes and later followed by the subjective aesthetic form that the architect can build on.

4 D El-Zanfaly, "*Design by Algorithms: A Generative Design System for Modular Housing Arrangement,*" 1 - 2.

As the function of the building is a part of my design dilemma, the case study buildings are appropriate ways to determine the baseline of understanding of how a Performance Art Centre performs as the use of an algorithm partially resolves the dilemma. It is wise to provide several similar case studies to my proposed site as the notion for functional spatial arrangement struggles with the design aesthetic. The generation of three sets of numbers of outcomes allows the architect to make an aesthetic design decision within the useful spatial data analyses- this may be related to tools like *"Massing models for volumetric studies"* [5] easily.



Massing Models for volumetric/ spatial studies

5 Kurmann, Elte, and Engeli, *"Real-Time Modeling with Architectural Space"*, 810-11.

Methodology Approach

General

The result is a hypothesis about what has been explored, rather than a concrete design with meticulous details. It is a study of spatial arrangement between the design stages of research and conceptual stage, with the use of computer as an aiding tool.

Different methodology has been used at different points in time during the development of the scripts. Consequently, there has to be a constant rethinking of the processes. As one identifies the problems, one must also research to discover a solution. Later, the proposed solution will be substituted, and one must continue to re-critique the new results. This question will become an exploration with explanation throughout the processes of trial and error. Therefore, each trial and error in this methodology approach will be further discussed in each individual section of this document.

T.A.P.A.C, Western Spring

Maidment Centre, Auckland City

Bruce Mason Theatre, Pakuranga

CASE STUDIES

Reviewing case studies is vital as they form the major methodological approach used for the research.

Within my case study, three real-world Performance Art buildings located within Auckland City are investigated. As a designer, one must see the critical parts of designing a Performance Art Centre within an educational environment. Some commonality between the three buildings is later proposed, from which the "essence" behind the script is later created. Therefore, I have chosen the following three local PAC for later discussion:

- T.A.P.A.C (The Auckland Performance Art Centre) : Western Springs
  Next to Western Springs College Grammar school
  Four studios + one main theatre
  Absence of fly-tower.

- Maidment Centre : Auckland City CBD
  Within Auckland University campus
  One studio (smaller theatre) + one main theatre
  Absence of fly-tower

- Bruce Mason Theatre – North shore, Pakuranga
  Outside educational environment
  One main studio
  Fly-tower present.

Review of current state of knowledge

DIGITAL ARCHITECTURE

"...We would always justify beauty by looking to nature. And arguably, beautiful architecture is always been looking at a model of nature...

... . In the 15th century, the decimal point was invented. Architects stopped using fractions, and they had a new model of nature. So, what's going on today is that there is a model of natural form which is calculus based, which is using digital tools and that has a lot of implications to the way we think about beauty and form, and it has a lot of implications in the way we think about nature...."[6]

As we tumble into digital architecture, we realise the variations and possibilities of a new-era of design. As mentioned before, due to the lack of free form thinking of the technological device, it has no ability to judge the subjectivity of spatial arrangement the way a human would. In light of this, the theory behind giving a computer a set of subjective creative judgements has not been a surprising topic. In the 1980's, McLaughlin considered the ***'automation of creativity'*** [7] and, at around the same time, Takala also proposed a ***'neuropsychological human model for computer creativity'*** [8] [9]. Another option exists - a simpler simulation model that has the ability to produce a more unexpected result which allows the architect to benefit, known as the ***Bottom up Simulation***. Greg Lynn believes that there is a model of beauty by looking into nature.

6 Student, "Greg Lynn on Calculus in Architecture," in *Greg Lynn Form*, ed. TED TALK (USA2005), 00.00.00 - 00:01:33.

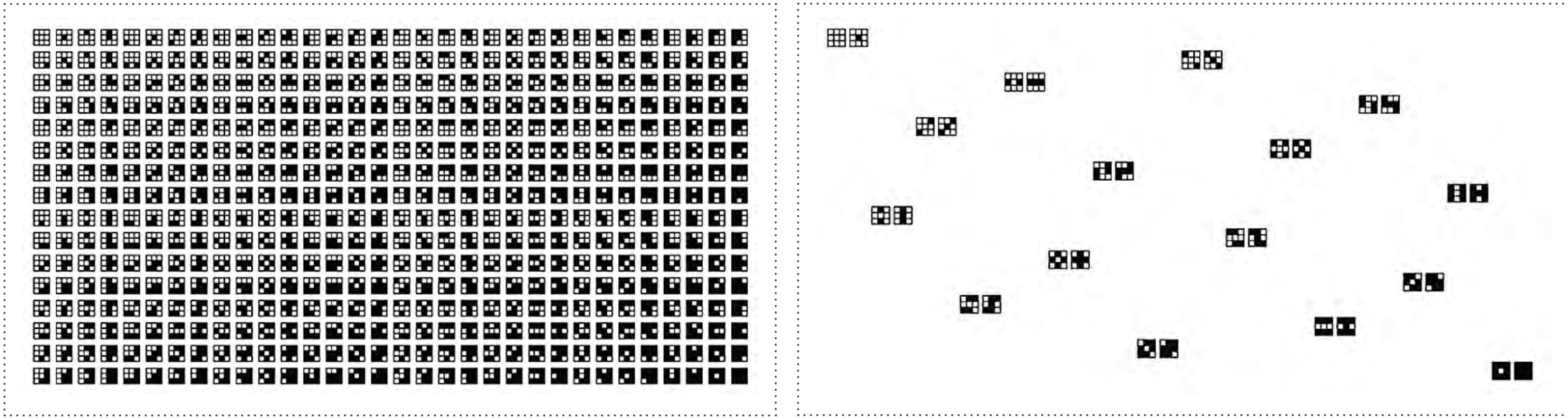
7 John S. Gero and Mary Lou Maher, *Modeling Creativity and Knowledge-Based Creative Design : Edited by John S Gero and Mary Lou Maher* (Hillsdale, NJ: Lawrence Erlbaum, 1993), 7.

8 Ibid., 106

9 Robert J. Sternberg, "Review: Easier Said Than Done," review of Modeling Creativity and Knowledge-Based Design by John S. Gero; Mary Lou Maher, *The American Journal of Psychology* Vol. 108 no.1, no. Spring (1995).

"... Take BMW as an example. They have to in 2005; have a distinct identity for all their models of cars. So the 300 series, or whatever their newest car is, the 100 series that is coming out, has to look like the 700 series at the other end of their product line. So they need a distinct and coherent identity, which is BMW, at the same time, there's a person paying $30,000 for a 300 series car, and a person paying $70,000 for a 700 series. The person paying more than the double doesn't want their car to look too much like the bottom of the market car. So they have to also discriminate between these products..." [10]

Greg Lynn's BMW example points out vital issues within the computer-generated architecture. It is often misunderstood as the computer is not limited to only 3D modelling or form-finding tools, but rather it can do much more if it were to be given a set of rules to act upon. The image below shows that Kostas Terzidis identified all the possible combinations of black and white for all nine squares in a 3x3 arrangement. As one can see, there are hundreds of valid possibilities that a human could undergo by the filtering method to make best use of the data- in this case, Kortas would filter all, leaving only those that are symmetrical.



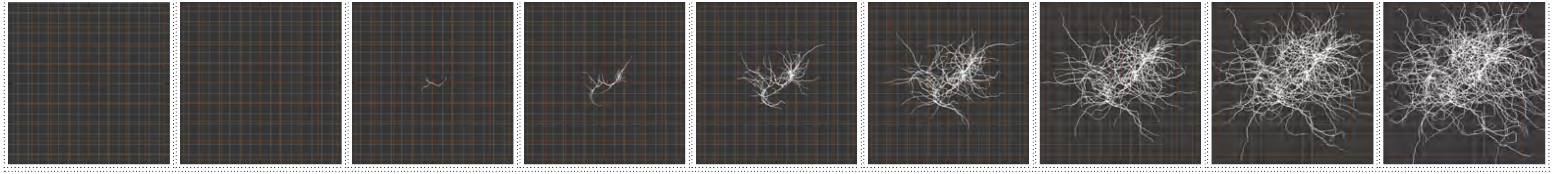
All possible combinations of black and white for nine squares in a 3x3 arrangement (left) and those that are symmetrical (bottom)

10 Student, "Greg Lynn on Calculus in Architecture," 00.10.57 - 00:12:00.

The 3 x 3 grids are very much like the BMW example, and the PAC also shares the same concept as it ranges from the least successful of the layout designs, to those that are most successful. It is possible for a programmer to give the computer access to the concept of aestheticism, but it is not useful for the purpose of research to write a different algorithm programme in order to analyse. Therefore, for this master design, I am applying my own aesthetic value with the three chosen, most promising results, for further development. In light of this, it is the architect's job to determine and later filter those that are irrelevant, leaving only the most successful ones for the architect to work on.

Bottom-up Simulation

A bottom-up approach is the piecing together of systems that give rise to grander systems, thus making the original systems from the emergent system. In the bottom-up approach, the individual based elements of the system are first specified in detail. These elements are then linked together to form larger subsystems, which then become linked- sometimes in many levels, until a complete top-level system is formed. This strategy often resembles a *"seed" model* [11], whereby the beginnings are small, but will eventually grow in complexity until its completion. However, "organic strategies" may result in a tangle of elements and subsystems that are developed in isolation and subject to local optimisation, as opposed to meeting a global purpose. As we all know, comparing between two trees that are of the same species may give little or no difference, the detail of the way the trees have grown and its branching are most certainly different. There is a computer theory behind the stimulation and the growth of a tree – the L-system script along with other similar plug-ins such as 3D Max's Guruware, Ivy-generator plug-in [12].



'Seed' / 'Growth ' Simulation by using Guruware Plug-in within 3D Max

11 CG Langton, *Artificial Life* (Citeseer, 1992).

12 Thomas Luft, "*Guruware - an Ivy Generator,*" http://graphics.uni-konstanz.de/~luft/ivy_generator/.

The simulation is closely related to the number of constraints, therefore, the simulation project mimics the properties of those in the real world within the virtual world, i.e. gravity and wind. The bottom-up theory has been the ideal one for my proposed digital arrangement, as it does not give a fix-end result, but rather a different possibility in each trial, depending on the circumstances of a particular trial i.e:

```
TRIAL 1:   1, 2, 3, 4, 5,  6,  7,  8  - sequence of (previous value + one)
TRIAL 2:   1, 2, 4, 8, 16, 32, 64, 128 - sequence of (previous value + its value)
```

As the example above is to represent how the bottom-up simulation operates, each sequence within the trial is largely based on the previous value – therefore, it gives different results each time, even though both come to an end within the eighth iteration. Similarly, as the agents move, its initial movement will dictate the following action and so forth. As previously mentioned by Greg Lynn, variation is extremely vital as it provides unexpected outcomes. With further extension and development, it is very much in the hands of the architect to build on the results.

Urban Morphology as computational systems

History Of The Theoretical Experiment

There are many workshops, both locally and internationally, experimenting within space generation, mainly within the study of the urban context – such as the generative urban design [13].

In 2009, Dina El-Zanfaly published her exploration of the applicability of algorithmic design in a real-world architectural context through the creation of a generative system for modular housing arrangements (MHAS). It is an interface in Autodesk Maya, based on stochastic search to produce various alternatives for modular housing arrangements [14].

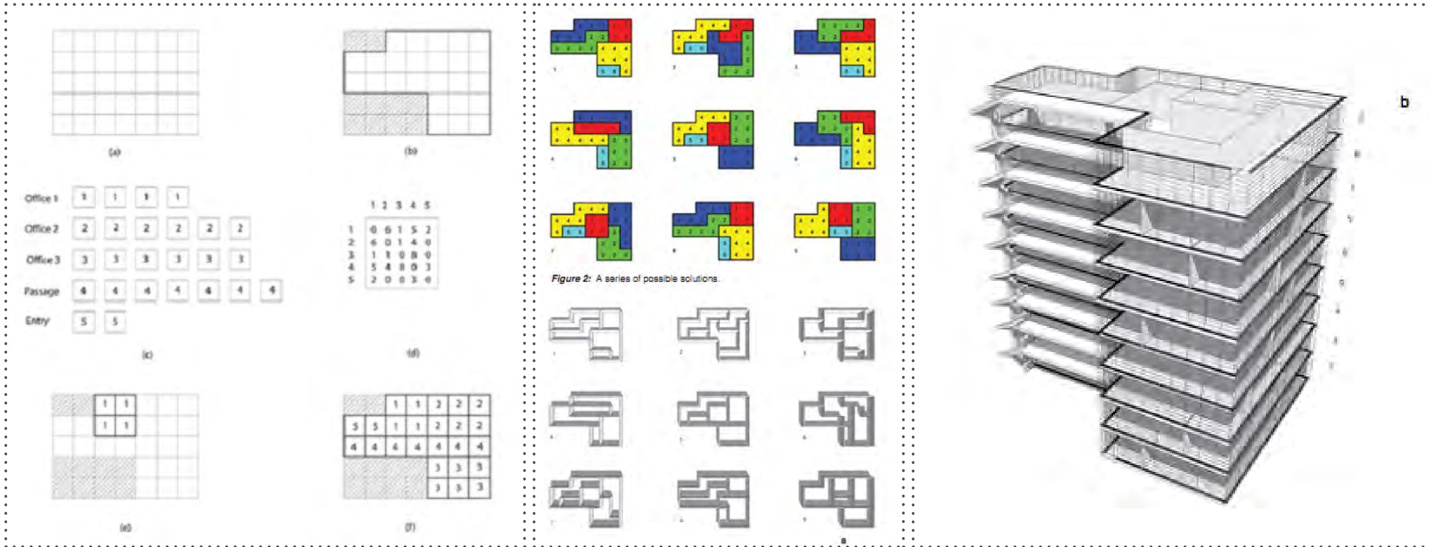
As we slowly focus from the arrangements of the urban space to housing module, we enter within an architectural space. A similar concept behind this experiment originated from the

13 R König and C Bauriedel, "Computer-Generated Urban Structures."; Bojana Vuksanović, "Planned Spontaneity," http://api.ning.com/files/tiV*Y9xZNOXpGxYG0xfHN54iI1ZDbCAUUEoVPdh81QG-d0fMMjc JLoSpFlLeGFGOK4ds1x7OVbfKe-3INedbDqlJ9RHuACcc/PlannedSpontaneity.pdf; Y Xu, "Design Architecture by Genetic Algorithm Short Paper for Ga2009."; ibid; P Rubinowicz, "Chaos and Geometric Order in Architecture and Design," *Journal for Geometry and Graphics* 4, no. 2 (2000).

14 El-Zanfaly, "Design by Algorithms: A Generative Design System for Modular Housing Arrangement."

automatic generation of plans from building programmes that were proposed by Dietz in 1974. It involves a unit system, site, programme, and an adjacency matrix of which the computer system could produce multiple solutions by trying various combinations of spaces allocated, very much based on the neighbourhood rules.

Kostas Terzidis later developed this further and published his finding in AutoPLAN[15]- a stochastic generator of architectural plans from a building programme. Its simplest manifestation, it calls for the production of an architectural plan without human guidance. In its so-called "automatic" nature. It poses a strange paradox where design is redefined not as an intentional articulation of form, but as a random reshuffling of spatial information under constraining rules until a possibility is met that satisfies an architecture function.



Kostas Terzidis Research in AutoPLAN

15 Kostas Terzidis, "Autoplan : A Stochastic Generator of Architectural Plans from a Building Program," *Harvard graduate School of Design, Cambridge, Massachusetts*, no. August 2007 (2007).

Case Studies

Case Studies #1

The Auckland Performing Arts Centre | T.A.P.A.C | - Western Spring

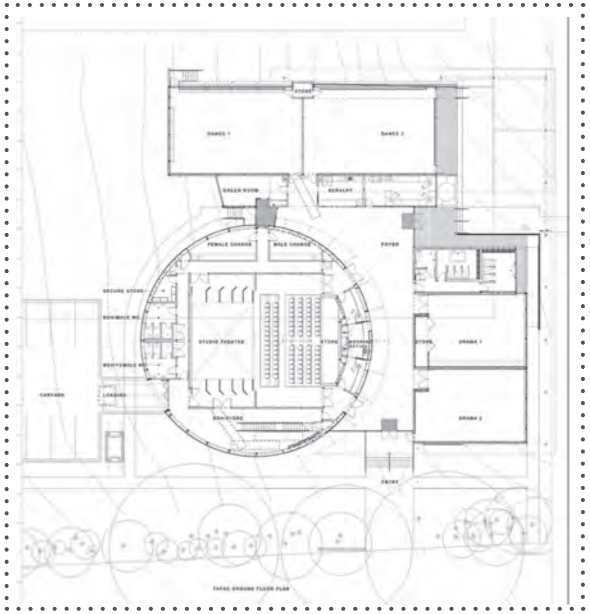
T.A.P.A.C is a stand-alone building for a Performance Art Centre. T.A.P.A.C is located next to Western Springs, opposite the Auckland Zoo. The building is embedded beside a high school, Western Springs College. After a discussion with Calvin, a T.A.P.A.C technician and Margaret-Mary, the T.A.P.A.C manager, they emphasise that architects should provide a Performance Art Centre based on real functional space. We also discussed the main issues of storage. Therefore, not only does the building not provide enough space, but it is a concern to the staff that the architect did not cover all aspects in order to achieve a successful functional storage space(s). There is an issue economically with smaller venues. This theatre is designed for an audience of 150 audiences budget has been an issue – as Calvin claims, this can be resolve by expanding the theatre to ideally seat 400.

As we critique the design of T.A.P.A.C from theatre user Calvin, claim that it would have been better to provide a volume for storage within a shorter distance, thus it would minimise the turnaround time for setup and take-down. As a suggestion to overcome the issues of storage, Calvin suggests providing a storage space for every main room, such as individual studio spaces or administration offices. By providing individual storage for individual spaces, it will not only reduce the distance, time consumption and quantity of labour, but categorising the storage items would give better access and management of the theatre.

The floor plan of T.A.P.A.C was composed from both circular and rectangular forms. As is well known the rectangular shape does not composite very well with the circular as it always results in left-over space. For its main theatre, the rectangular prism volume is fused within an outer cylinder volume, of which the architect has cleverly used the left over space (from the nature of rectangular shape and circular shape) to provide the performers with a corridor and backstage spaces. This is one of the spaces where Calvin noted that a storage space with a curved wall does not help

T.A.P.A.C

- *148 Audiences,*
- *no fix stage,*
- *no fly tower,*
- *no acoustic panel / speaker amplifier,*
- *no fix furniture seating.*



when storing move-able seats [16]. In the dressing room, it is an issue of concern that the curved wall does not feel welcoming. Calvin also mentioned that in their main theatre, space for a catwalk[17] should be provided, as it would reduce the time for setting up the required lighting or hanging objects needed for certain performances. He also mentioned that a three hundred seat theatre has no need of fly-tower facilities [18]. However, it is crucial for a Performance Art Theatre to be a flexible space where seats are not fixed and are able to be repositioned to suit a variety of performances.

Issues regarding acoustic measures in the small theatre space have also been brought to attention. The walls and ceilings are layered with sound absorbent materials or covered with acoustic drape, or some form of ***curtain***[19]. The control room is located in the upper stories, access being via the stairs located at the main theatre storage area. In the general theatre design, the control room is located opposite the stage. However, with the flexibility of the T.A.P.A.C there is no certainty to determine which is the front or back of the theatre. So the T.A.P.A.C theatre has a chance of exposing the control room to the audience. While entering the theatre, the audience will need to pass through a room called the Transition Room, a room which filters the exterior environment from the interior.

It is intriguing to find circular forms that can be sensitively placed in contrast to other rectangular spaces. In doing so, the theatre itself becomes the main focus of the whole building whilst the other studio spaces appear to be complimenting it. As a result, T.A.P.A.C's architect successfully created spaces and volume which are in relation to one another. The box office and the office itself are located next to the main entrance and facing off the studios walls. Within the public corridor, the architect played with the idea of contrast between the linear studio walls against the theatre's curved wall to benefit a more playful space. However, the curved wall is shielded with corrugated metal and with skylight ceiling located just above the cladding. Unfortunately, the corridor may easily heat up and many users have complained about the reflected glare due to the metal-

16 Ernst Neufert et al., *Architects' Data*, 3rd ed. (Oxford ; Malden, MA: Blackwell Science, 2000), 478-80; Ian Appleton, *Buildings for the Performing Arts : A Design and Development Guide* (Boston: Butterworth Architecture, 1996), 117-33.

17 Catwalk – (ktwôk) – A narrow, often elevated walkway, as on the sides of a bridge or in the flies above a theatre stage. "http://www.thefreedictionary.com/catwalk"

18 Fly-tower allow s scenery and also stage lighting and sound to be suspended over the performance area, off bars capable of being raised so that they are out of sight of the audience.Appleton, *Buildings for the Performing Arts : A Design and Development Guide*, 148 - 50.

19 Ibid., 148.

lic cladding.

The concept of a studio theatre, located along the north side of the building, is to be able to convert the space into an outdoor stage. It challenges the very idea of the enclosed theatre where performances can be carried out to the public for one to interact with and be engaged to.

During the site tour, each space was entered. A number of spaces designed by the architect are currently used differently by the users of the theatre. The Green Room, assigned by the architect for performers to warm up in, is now used as an office space as it is too small for its original purpose.

Maidment Centre, Auckland City

Maidment Art Centre

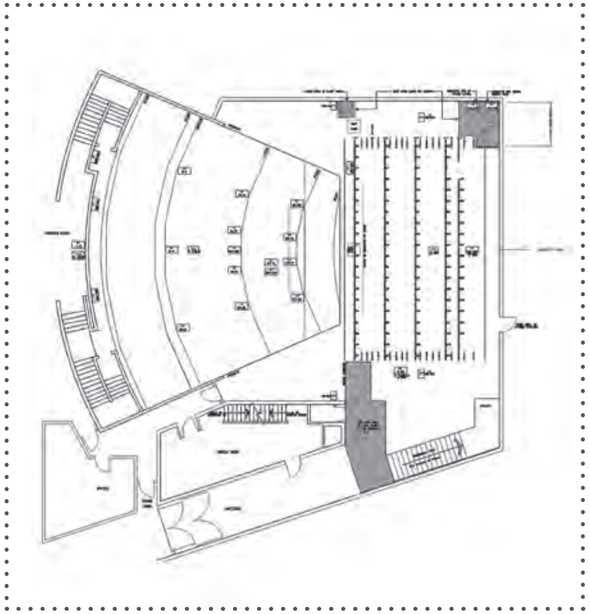
- *448 Audiences,*
- *fix stage,*
- *no fly tower,*
- *uses acoustic panel / speaker amplifiers,*
- *has fixed seating.*

Case Studies #2

Maidment Art Centre - University of Auckland

The Maidment Art Centre is a theatre which was originally built in 1976. In later years, the theatre was remodelled for better fit to today's activities. The theatre is located across from the University of Auckland's General Library. The centre provides two theatres, one that could fit 104 members of the audience, and the other 448 seats. In the early designs of the Maidment Art Centre, the foyer was originally created with the intention of an outdoor experience, whilst the foyer was to provide a connection to an internal courtyard of the University of Auckland campus. However, the concept no longer works to the benefit of the performance arts due to distractions from noise and trespass. Therefore, it is now an enclosed foyer, but with the possibility of access to the courtyard. Paul, a staff member who offered to help in explaining how the Maidment Art Centre is used, commented on the 400-450 seats that is ideally reserved for a Performance Art Centre located inside an educational environment.

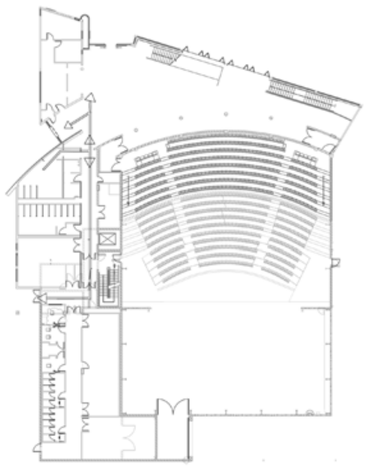
Paul has great experience and understanding of the Maidment Art Centre. The first thing he mentioned was how the building preserved a significant history from its very first use till today. The second most crucial information was the lack of storage and bigger loading bay. The design of the building originated without any spaces provided for staff offices. After the remodelling in the early 1990s, the new design provided not only new office spaces, but it has also improved the circulation space between the staff and theatre. Paul discussed the impossibility of multipurpose function for a theatre, and came to the conclusion that today's solution to get around



this crucial issue is the use of technology. As it is no longer necessary to meet every acoustic criteria for each type of performance, Paul advised me to focus on the generalisation of a theatre space, and to patch-up any acoustic adjustments with a speaker. The speaker adjustment is faster and requires less labour consumption than the manual process of acoustic panel readjustment.

As we entered the studio theatre, Paul pointed out the building services, referring specifically to the air condition vault that is placed in a rather awkward position. Not only does it produce a large humming noise, but it is also visually unpleasing to the eye. His advice during the design stage was that the architect should understand and be aware of how some services can discourage its purpose to the space. Before the 1990s refurbishment, the seating around the lecture theatre was not fixed, giving a better option for types of performances used in the space. However, due to the new fixture of stepping floors and to the lack of central stage performance, the seats have now become fixed. Within the studio theatre refurbishment, the architect seemed to have not taken the audience into consideration. However, in this shoe-box form of a studio theatre, there is a lack of space for the performers backstage. Without a back-corridor pathway that allows a performance to re-coordinate itself from left to right behind the stage, the performers are forced to perform without making any changes from stage left to stage right. Thus, performers have to travel behind the audience to get to the other side of the stage.

As Paul gave us an opportunity to critique the Maidment Centre, we toured to the upper level where we reached an isolated control room. It is acoustically separated from the main theatre, while preserving a visual connection to the main stage. Within this small space, one must move about, controlling a number of different switches. As we travel past the control room we reach the beginning of the track bridge of the catwalk which has very little head room. This lack of head room not only slows down the process of lighting installation, but makes it a rather unpleasant space to work in.



Bruce Mason Centre

- *1164 Audiences,*
- *fix stage,*
- *has fly tower,*
- *uses acoustic panel / speaker amplifier,*
- *has flexible fixed furniture seating.*

Case study #3

Bruce Mason Centre - Takapuna

Bruce Mason Centre, located in the heart of Takapuna Beach, North Shore.

The Bruce Mason Centre is a popular and unique venue for performing arts, conferences, exhibitions, product launches, gala dinners and weddings. Bruce Mason provides the community a promising world class auditorium. Andrew Scott, the Chief Executive of the Bruce Mason Centre, describes the auditorium to be of world-class acoustic level with clear sight lines to the stage, thus making it one of New Zealand's finest venues for the performing arts. The auditorium provides a wide range of shows from orchestral concerts and musicals, to ballets, comedy, and children's entertainments.

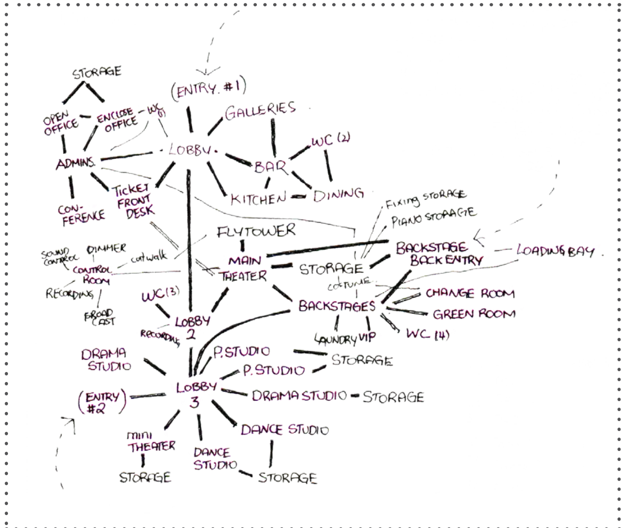
The auditorium has several possible modes, and at maximum can seat 1164 people in the audience- theatre style. In this mode, there are 916 downstairs in the stalls, and 248 upstairs in the Grand Circle. Intriguingly, the centre has the ability to convert the auditorium to one of Auckland's largest flat floor banquet areas, capable of seating six hundred guests. In this mode, the auditorium is ideal for dances, award dinner ceremonies, balls, exhibitions and gala functions.

The centre has only one main theatre and a conference space. As we enter the Bruce Mason Centre, we reach the atrium space where one could see a curved wall, signifying the back wall to the fan-shaped main theatre. Therefore, the transition and the distance from the entry to the audience to the main theatre is very short. As to the side of the main theatre, the architect occupied both spaces and made it into the performance preparation space, such as dressing room and the Green Room. The audience is only able to occupy the atrium entry space. The centre is embedded on a very steep sloping site, thus giving opportunity to have multilevel to the back of the theatre-backstage area. This is useful as the backstage is within PAC design that lacks a larger floor space.

Within the Bruce Mason's auditorium, Scott strongly critiqued the problem they have with the turn-around time. Preparing and setting up all the required necessities for a particular performance has been the main issue for staff members at the Bruce Mason Theatre. It has been predicted there will be high labour turnaround time of eight hours spent on installing or removing the auditorium seating. Thus, this has been a major financial issue for Bruce Mason Theatre. Furthermore, one would see something unique in the control room. The control room is usually an enclosed space from where the staff can moderate the sound and/or light to fit certain acts within a performance. Much more interestingly, it has been opened and integrated into the audience seating, giving staff a true visual and audio connection from a different angle.

The architect of Bruce Mason Theatre provided high-tech equipment to adjust the acoustic ceiling panels, but within a certain limit. It is too much bother to re-adjust each time according to different types of performances, thus Andrew Scott mentioned that it would be much easier to stop adjusting the panel and remove the acoustic dilemma by installing additional audio speakers.

Summary Of The Three Case Studies



To summarise the case studies we have explored, several similarities are shared by the three PAC. Between these three PAC, the importance of spaces are discovered by listing all the spaces used, and finding which spaces have the greatest connection over others. From the results, we could arguably categorise the three major spaces while the minor spaces are 'attached' to the major spaces. The three major spaces are the main lobby, main theatre and the theatre's backstage. Those three spaces are commonly bound and fixed with a strong connection. While designing the PAC building, there are much more fixed variables to the spaces, ie. the fly-tower would requires a certain height, depending on the stage opening, the backstage a certain volume for the performance preparation and accessories, and for the best acoustic performance within the functional space, the main theatre must have the right shape and volume requirement. Therefore, one may doubt how much the script would be generated as the rules are extremely restrictive. On the other hand, the computer also has the ability to give results from more complex data.

A rough sketched bubble diagram showing how these minor spaces relate to major spaces are shown in the image below. As displayed on the sketch, not only does it show one solution to a possible spatial arrangement, but it also does not contain the value of the site information, thus the architect is clueless regarding how the required spaces relate to the site.

Project's Context

Project Briefs

The stage is the most vital part of the theatre as, aurally speaking, the dynamic contrast emitted from the stage, such as those from a philharmonic orchestra, will need to be exaggerated to create the same effect in theatres that are of different shapes. The dynamic contrast is less obvious in theatres that are of a circle-shape due to the way the sound travels and reverberates around the walls. Based on the three case studies and researched data that I have collected; the following spaces are required for my PAC design:

SPACES REQUIREMENT

Pre-function Spaces	
Lobby / Galleries / Foyer	144 m2
Small kitchen / bar	70 m2
Toilet	100 m2
Administration	
Open space office	100 m2
Enclosed office	30 m2
Ticket booth / Front desk	8 m2
Storage	18 m2
Conference room	64 m2
Cleaner room	4 m2
Security room	6 m2
Educational centre	
Dance studio	378 m2
Drama studio	288 m2
Performance studio	252 m2
Mini studio	40 m2
Storage	54 m2

Main theatre

Transition room	8 m2
Adaptable 300 - 350 seating	784 m2
Stage	102 m2
Fly-tower	15m High *with 5.5m height of stage opening*

Theatre backstage

Side Stage related spaces	68 m2 (both sides)
Green room (resting space)	200 m2
Dressing rooms	60 m2
W.c / shower	60 m2
Guest room (VIP performance)	25 m2
Laundry	4 m2
Storage	300 m2
Secure storage	9 m2

Service rooms

Control room	15 m2
Recording room / broadcast	35 m2

Catwalk facilities
Separate entrance
Loading bay
(with direct access to stage)

+10% circulation area: 0.10 x 3126m2

TOTAL Space area: 3 438.6 m2
Site Area with courtyard: 3 153.0 m2

Site Analysis

The chosen site for the design research is located inside Mt. Albert's Unitec Campus. The site is located between Building 09 and Building 06- "Performing and Screen Arts". In the current site analysis, the proposed site provides a number of advantages by providing a beneficial performance art centre for students and locals. By providing a stage where art can be freely expressed, it may awake and provoke further opportunities for the student's and local's art and cultural activities. This would also reflect Unitec's image of "real world learning." I propose a full operating performing arts centre to be located next to the current school of performing arts. Thus giving students an opportunity to experience performance and equipment with the required procedures. However, the site also presents a number of concerns and restraints, such as the availability of land area and unique context. However, the most important is the historic building constraint. In a highly restrained proposed site such as this one, it presents challenges and thrills in developing stages that can be considered a 'unique design'. I also foresee with those site constraints.

Building 06 - "Performing and Screen Arts"

Building 06 - "Performing and Screen Arts"

Current existing Dance School / Studio

History Of The Site[20]

The Unitec Institute of Technology campus was renamed and formed in 1994. The upper part of the current campus was originally a psychiatric hospital, the Carrington Psychiatric Hospital for the Idiots[21]. In 1865, the main Carrington Psychiatric Hospital (currently known as Building 01) was built. A new wing was added in 1881, followed by a further extension to the South in 1886. In 1903 and in the 1950's, the hospital was forced to provide an extension of facilities due to the increase of patients. In 1976, the southern side of Mt Albert Campus was built as the "Carrington Technical Institute" and later incorporated the buildings of the former hospital in 1992. During a discussion with George [22], we discovered that Building 06- the bricked building located at the West side of the proposed site, was built at the same period as Building 01. As to the building to the East of my proposed site- the Human Resource building, it was originally used as accommodation for doctors and nurses. The Southern end of the proposed site is the Film and TV Screen School, which was historically used for the hospital's storage warehouse. However, the Dance School building is not historically listed, although it is taken into consideration that part of the Drama School is an annexe of this historic building. This information is crucial as it shows that my site is mostly post-construction of historical buildings. It is a main concept of Adaptive-reuse.

Existing building

The site is situated in an area which is surrounded by a number of different art schools. These schools do not only include the Fine Arts [23] but also those arts that require movement. Such schools involve the Art Studios, Workshops, Drama, Acting, School of Architecture and the School of Design. By providing a space where the local community could be involved in activities, students' artworks could be placed on display. It may enrich the community to contribute to new artistic ideas. The site is surrounded with mid Neo-architecture buildings which have been adapted to suit the current schools' purpose. The major existing building, Building 06, was designed to have a

20 Unitec Institute of Technology, *"A Building Known as Carrington"*, ed. Robyn Walshe (Auckland 1994).

21 Ibid., 1 -2.

22 George Corbett, Unitec Staff - Contracts and Compliance Coordinator Facilities Management - Admin

23 fine art,(n) - art produced chiefly for its aesthetic value, as opposed to applied art; Also called beaux arts any of the fields in which such art is produced, such as painting, sculpture, and engraving, Collins English Dictionary – Complete and Unabridged © HarperCollins Publishers 1991, 1994, 1998, 2000, 2003

Building 06 - Lower Main Entry

Building 06 - Windows and services

Building 06 and Dance school

One-way Road

long single corridor with space divided along both sides. As we critique the space, there are many stages of annexes to the building, thus creating a very awkward floor space. However, the basement of Building 06, is dark, humid and has contained spaces.

Uniqueness

The site which has been proposed is to positioned beside two major parking grounds in the northern end of the Unitec campus. The main Building 01 parking space is currently being allocated to student parking within the. Due to the proposed building operating mainly in the evenings, these parking spaces are a generous amount for the audience, guest artists and staff members. By having two gates to the site from Carrington road, one entry could potentially provide intimate privacy for activities performed by guest artists or backstage users, and the other would be the audience's entry. The site has an advantage for a designer to create a separate entry for both the audience and the performers, as recommended by PAC users. This also means that the extra equipment needed and provided for the evening performances will be carried into the Centre without any disturbance to the entrance for the audience. It is understandable that the requirements of both entries is different, thus with its existing context, a better organised entrance must be provided.

Inside the campus of Unitec, trees are planted as if inside the preserved park. Within this context, there are a group of trees which give the site a unique environment. Due to this, trees within the proposed site are an essential element to the uniqueness of this site. The site slopes downward towards the main car park of gate 2 and Building 06 while it also tilts up towards the Human Resource building. Within the site, there is almost no noise from the main road because the site itself leaves an impression of isolation as it is in the heart of the campus. This is an advantage to provide a space where people can develop their creativity and express themselves freely.

There are many routes (footpaths) which one could take to reach the proposed site, but the most popular is the route which passes through the existing centre courtyard which is framed by Building 06 and the Dance building. The current Dance building has a main entry located in the Eastern facade. However, people, mainly students, do not seem to use what is intended to be the main entry, as entering through the internal courtyard appears to be somewhat more appealing. Entering through the North/South facing the courtyard, one may see that it is an ideal space where people could more likely interact, whether between the students themselves or, staff members.

The long facade of Building 06 faces the East and the West. Building 06 has a facade made of red brick which could potentially be used for thermal-mass. As for the Dance building, it is covered by white corrugated galvanised iron. Half of Building 06 is two stories high with a basement, whereas the Dance building is a single storey building with high ceiling space. As previously mentioned, the site slopes down from the Dance Building to Building 06 and the Gate 2 parking lot. As a result, the Dance Building appears to be higher when compared to the Building 06's.

Site Analysis + Script

Within this project, I propose to demolish and re-design the current Building 07 (Dance School); opening a window of opportunities to design a better, and more centralised gathering space. The current state of the building form centralises the courtyard between the existing Dance School and Building 06. This has been the architect's best action by providing a courtyard to form a space for social gathering. However, after further talks with performance students, I have come to an understanding that the courtyard is also rarely used. This is due to the Auckland weather where it creates an unpleasant and muddy environment. One must also realise that it is a very small courtyard which gives uneasiness to the whole environment as literally everyone's activities done within the courtyard would have no sense of privacy.

Regardless of those issues, the Dance Building fully equips space for the students' studios. However, after comparing both my chosen case studies' theatres and of the current Unitec theatre, it has come to my attention that a proper Performance Art theatre should be properly introduced to Unitec's School of Performance in order to prepare students for the up-coming professional performing industry.

New alternatives in architectural designs for a better outcome will be experimented using computer algorithm. Therefore within this project; one is to presume that Building 07 no longer exists for modelling purposes.

Computer Scripting Theory

Variety Of Computer Scripting Theories

> *"The difference between scripting and manual design is in the complexity and unpredictability of the actions. The human designer may be constrained by quantitative complexity. End user programming languages have allowed designers to take advantage of the potential of the computer's processor to perform a very large number of calculations manipulating complex geometry through scripting."*[24]

At the earliest stage, I decided to perform an experiment on a method which 'Spatial massing model'. As shown in the image, each coloured block represents a space. Ranging from the initial design to the actual design stage, those cubes serve great value for the architect to uncover and explore the spatial relationship within its given site. This traditional method of exploring the space relationship is closely re-examined as not only the physical cube model takes time to make, but often a chance where the architect limits himself to a solution, oblivious to other possibilities it may hold. In fact this technique can provide dilemmas in which the architect may place spaces that are not valid in relation to it. Here With the computer we can uncover the potential of space arrangement by the simulation of *'growth'* [25].

Programme Chosen For This Experiment

After further research for the appropriate program to use, Netlogo became the preferred choice. This programme is originally a tool given to further research in understanding of how the world behaves the way it does. However, the reason I chose that is due to its *multi-agent capability*[26].

24 El-Zanfaly, "Design by Algorithms: A Generative Design System for Modular Housing Arrangement."

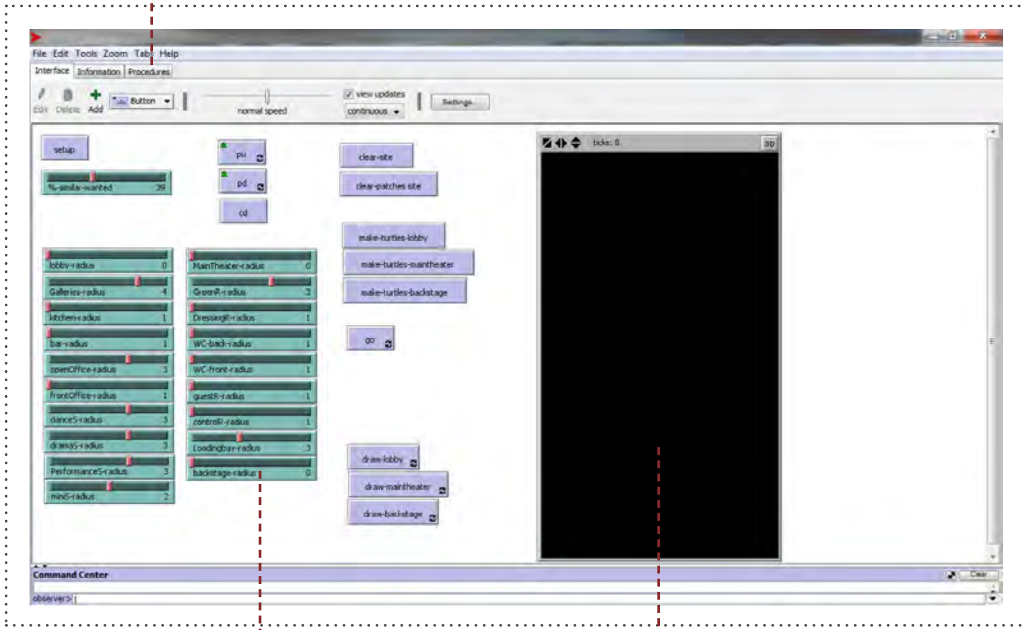
25 P Coates and R Thum, "Generative Modelling," *London: University of East London* (1995). S Tisue and U Wilensky, "Netlogo: A Simple Environment for Modeling Complexity" (2004).

26 SF Railsback, SL Lytinen, and SK Jackson, "Agent-Based Simulation Platforms: Review and Development Recommendations," *Simulation* 82, no. 9 (2006).

After the survey of the case studies and further uncovering numbers of different algorithmic or scripting tools available, Netlogo was selected for the study of this project due to the following reasons:

- Easiest to learn and to understand
- No requirement of advance scripting skill
- Provides numerous lists of pre-scripted library of models as tutorial
- Has the opportunity of supervision from an experienced Netlogo user

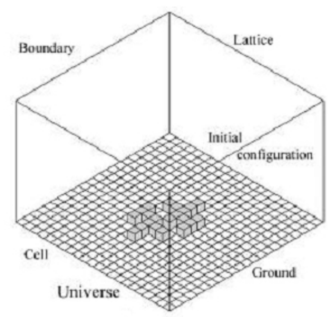
Netlogo[27]



Netlogo is a programmable modelling environment for simulating both natural and social phenomena, it is a scripting programme. This program is well suited for modelling complex system that develops over a period of time. Indeed, it makes it possible to explore the patterns that emerge from the interaction of many individuals (i.e. Cellular Automata, L-system). Within the model library there have been a number of examples and experiments carried out by the programmer to further use computer logic for their research. There are examples which range from art and mathematics, to microscopic organisms and natural behaviours. As to this exercise, Netlogo has the advantage to give modellers instructions to hundreds or even thousands of independent 'agents' to simultaneously operate. This makes it possible for a modeller to explore the behaviours of each space (agents) as it responds to each other.

27 "Netlogo ", http://www.netlogo.com.

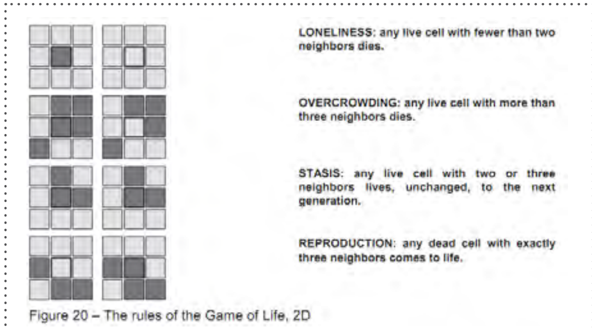
Within Netlogo, there is an environment called the ‘Netlogo world’. The Netlogo world consists of agents. Agents are beings that have individual rule properties, or, as I would like to call it, ‘ behaviour’. Those scripted behaviours allow agents to carry out their own activities simultaneously with careful calculated moving paths in relation to the others. Therefore, writing, or defining, the rule of their behaviour within Netlogo is called ‘Scripting’ i.e. the computer will understand the word ‘ball’, or ‘gravity’. The computer may not need to know the scientific side of how exactly a real ball would drop due to the Earth’s gravity, but it can simulate in a similar fashion to the real world how the ball behaves. This is achieved by scripting the value of the gravitational pull, the surface tension and the weight of the ball, but most importantly, the reaction which one foresees. With Netlogo, there are many methods and types of simulation which try to replicate our understanding of our universe. With each simulation, there must be a script. A computer script alone collects codes and allows the computer to understand and to predict the outcomes. However, it proves that one’s theories can be further explored.



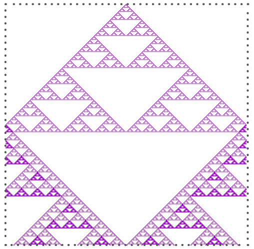
In Netlogo there are four types of agents: turtles (moving agents), patches (boundary agents), links and the Observer. Turtles are agents that move around in the world. The world is 2D which is divided into grids of patches which are called *‘cells’* [28]. Each patch is a square piece of virtual ground that turtles can move about in. Both patches and turtles have coordinates, while their differences exist. Patches coordinate in values by integers, while the turtles coordinate in decimal placing. Inside the Netlogo world, it is divided into pixels of cells, of which it relates back to the patches it coordinates in (0,0) - origin. This may be the limit of which the computer would understand the creativity. Furthermore, this in time will aids architects in perfecting their design by using the earliest templates of the required space in relation to its site.

28 RJ Krawczyk, “Architectural Interpretation of Cellular Automata” (2002), 2.

Cellular Automata computational framework



J.V.Neumann CA - "Game of life"



CA's Pattern - CA 1D Rule 90 model

As a computer is a 3D modelling tool that allows one to stretch, fold and distort 3D forms with virtual forces, the volume of architecture could be easily enhanced to its maximum potential.

The self-replicating systems, theoretically introduced by John Von Neumann, are widely examined in biology, computing, geometry and engineering sciences.[29] Cellular Automata is often known as the ***"game of life"*** [30] where it is at its earliest form of experiment to investigate the possibilities of the concept - Bottom-up simulation. This game consists of a collection of cells which, based on a few mathematical rules, can live, die or multiply. Depending on the initial conditions, the cells form various patterns throughout the course of the game. The purpose of this game is to study and discover the emergence and self-organisation. To simplify, Cellular Automata is a computation framework that a cell, piece of software, machine, or the like, can replicate itself. In this study, it is initially predicted that the concept of Cellular Automata (CA) may be a possible method in this process of spatial form generation study. Not only is CA a mathematical based computation framework, but the outcome also has an abstracted volume, and indeed, quite unpredictable.

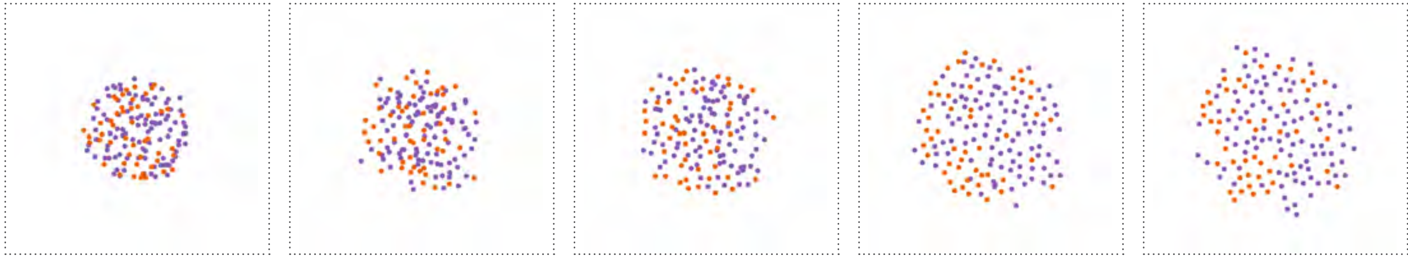
29 PM Torrens and D O'Sullivan, "Cellular Automata and Urban Simulation: Where Do We Go from Here?," *Environment and Planning B: Planning and Design* 28, no. 2 (2001); L Petrusevski, M Devetakovic, and B Mitrovic, "Self-Replicating Systems in Spatial Form Generation-the Concept of Cellular Automata," *spatium*, no. 19 (2009); Coates et al., "The Use of Cellular Automata to Explore Bottom up Architectonic Rules"; M Devetakovic et al., "Les Folies Cellulaires–an Exploration in Architectural Design Using Cellular Automata."

30 "Netlogo Model Library- "Game of Life"," http://ccl.northwestern.edu/netlogo/models/Life.

'Cellular Automata' Roadblock

I initially agreed to explore a computer simulation method called Cellular Automata (CA). CA as initially thought, would advance and validate my theory of using computers to generate spatial arrangements. However, the theory behind CA's advantage is to have a random self-organised system, but restricted to the spatial arrangement within architecture, there is a form of hierarchy in spaces that distinguishes the spatial connection. During the trial, the data given from CA was too chaotic and it is highly depended on its 'neighbourhood'. In the past, CA has been incorporated into architecture design as it can manipulate into an interesting form, however, it lacks the ability for spatial arrangement. As it turns out, this issue was resolved with other algorithmic methods due to the amount of inconsistency data from CA.

Cellular Automata To Agent-Based Model



Scattering Sequences within 'Scatter model'

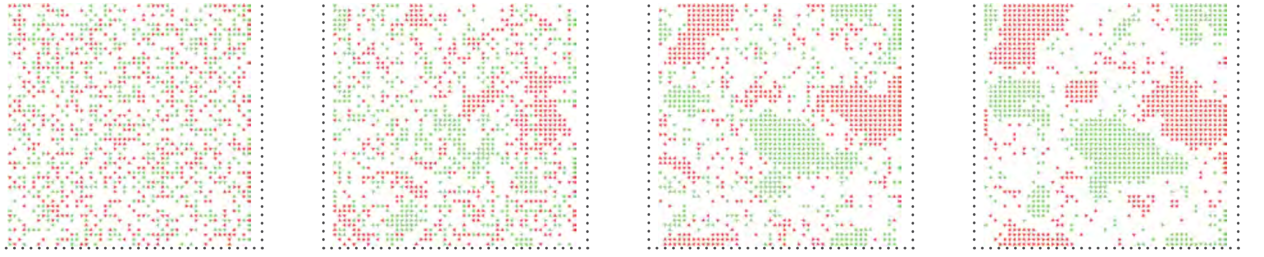
An alternative method is to use the Multi Agent System (MAS), also commonly known as the Agent-Based Model (ABM)[31]. The Multi Agent Systems process characteristics are similar to those of CA. In any given context, each turtle contains a set of rules embedded within it. Therefore, turtles are able to navigate their own way freely and explore any given spatial environment. To reiterate, CA is rather different because CA is constrained by its ***surrounding neighbourhood***, thus it cannot respond as easily as the Multi Agent Systems. In the context of what we are trying to achieve, the Multi Agent Systems has some discrete regulation which allows the computer to understand its virtual surrounding to its 'real' surrounding. This is vital as it helps the outcome given from the script better use for architects. Thus we move our focus from the CA system to a Multi Agent System known as the ***"Scatter model"***. This model is preferably ideal to simulate groups' behaviours

31 PR de Andrade et al., "An Architecture for Agent-Based Modelling and Simulation of Geospatial Phenomena."

as they start to group or scatter in a social environment. This model we see has the potential to be investigated as it has the quality of grouping certain spaces together and repelling those that are not in these categories[32].

The essence within the scattering model is quite interesting as we later discover a similar model called ***'segregation'***. It is different, yet we see both models to have potential in providing a successful initial design template for the architect. Within scatter model, there are only two types of turtles (agents) with each having their own properties. In the initial stages of the scatter model, both types of turtles grouped close to one other are parallel to the other model run where the two groups of turtles start to find their places as they spread across to the virtual world. Consequently, the rules are to attract those that are similar to itself, or have the potential to connect with one another to form a closer bond. Therefore, we introduce Segregation modelling as it has a very similar modelling principle.

Segregation Model



"This project models the behaviour of two types of turtles in a mythical pond. The red turtles and green turtles get along with one another. But each turtle wants to make sure that it lives near some of "its own." That is, each red turtle wants to live near at least some red turtles, and each green turtle wants to live near at least some green turtles. The simulation shows how these individual preferences ripple through the pond, leading to large-scale patterns.

This project was inspired by Thomas Schelling's writings about social systems (such as housing patterns in cities). " [33]

32 "Netlogo Model Library- Scatter," http://ccl.northwestern.edu/netlogo/models/Scatter.

33 "Netlogo Model Library- Segregation," http://ccl.northwestern.edu/netlogo/models/Segregation.

The programme is a rather close imitation of Schelling's original model. It consists of a *"city"* made of a square grid, in which two groups of "inhabitants" live. The X and the Y are initially randomly distributed around the city. Each inhabitant has a certain number of "neighbours"; these are the agents occupying the eight squares which surround the square that they "live" in. Thus, each inhabitant can have between zero and up to eight neighbours. Furthermore, the city is not an exact square, but a 3 - Dimensional "torus" (Unlimited loop), which means that the upper edge touches the lower edge, and the right touches the left, such that the city becomes border-free.

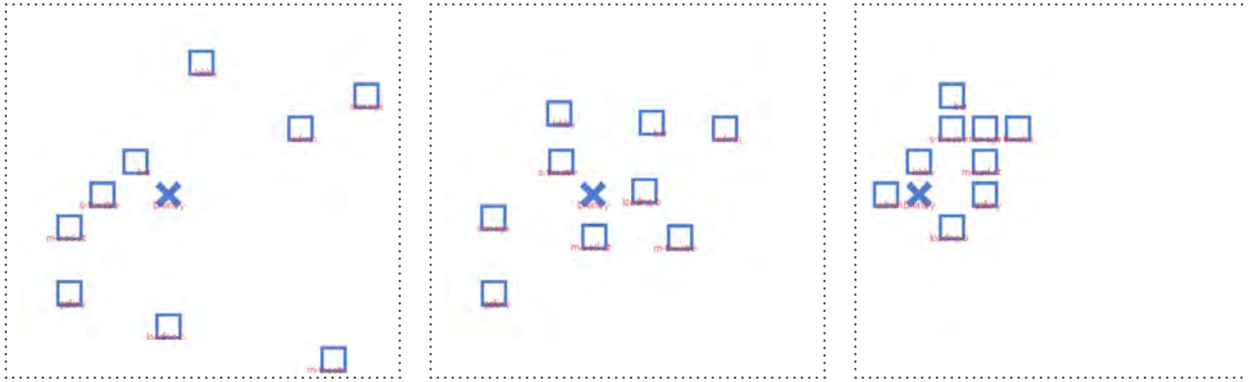
Now, as in Schelling's model, we let the inhabitants evaluate their current location based on certain preferred rules. These rules determine whether or not an agent is happy with its current location.

Segregation Model And Spatial Relationship

Looking into 'Cellular Automata' which has the self-organising system; we then followed closely into 'scatter modelling' which has the potential of repelling certain turtles. At last, we came across the "segregation" simulation which has the ability to understand the boundary and gives each the turtle (agent) an individual 'behaviour'. Within this model, we could figuratively treat each space as a rule based on living organisms or chess pieces. As each chess pieces is locked into 8 x 8 cells of a chess board, the pieces have their own rules and boundaries i.e. the pawn can only move forward, and the King only a one-square-movement around its neighbour. With that concept in mind, we could develop the beginning of a valid script.

Earliest Segregation Modelling Trial

In the first successful segregation script, the initial stage showed a very promising result as it suggested the possibility of using this method to be a part of the design process. This initial script is not included in the variable site boundary to the Netlogo world. Therefore, within this trial, there is no site consideration during its calculation. Advantages of this script were later found, and the amount of time consumed was reduced to understand the spatial spaces. One was able to foresee the advantages of being flexible in moderating certain parts of the model to fit in with design changes made while keeping in mind that preserving valid end-data is vital, i.e. we could change the imported site file to a different location, getting the Netlogo to simulate a new variable site.



Within this trial, we have used ten agents symbolising ten different types of space. As the table below shows, each turtle was split into five columns, each categorised by a space number; turtle's identity; which turtles were attracted to what, and what the turtles were repelled from.

Trial #1	Space number	Like	Dislike
Lobby	1	2 3 5 9 10	6 7 8
Studio-T	2	1 4 6 7 8 10	9
Main Theatre	3	1 4	2 5 6 7 8 10
Backstage	4	2 3 5 6 7 8	9 10
Admin	5	1 2 3 6 7 8 10	4 9
Loading bay	6	4 5 7 8	1 3 9
Back-entry	7	4 6	1 2 3 5 9
Storage	8	2 4 5 6 9	3 7
Galleries	9	1 3 5 10	2 4 6 7
Bar	10	1 3 9	2 4 5 6 7

These space data then later scripted into java script (Netlogo's primitive computer language) as such:

```
ask turtles                              ;; Run command "turtles"
[ if who = 0                             ;; Turtle 0's number
 [ set label "lobby"                     ;; Name for Turtle 0
   set space-type 1                      ;; Turtle 0's Space Number
   set happy? false                      ;; which made turtle 0 move from its
                                              Initial placement
   set space-like [ 2 3 5 9 10 ]         ;; list of turtle 0 space number
                                              which this turtle like
   set space-dislike [ 6 7 8]            ;; list of turtle 0 space number
                                              which this turtle dislike
]                                        ;; end of turtle 0 command


  if who = 1                             ;; Turtle 1's number
 [ set label "s-theatre"                 ;; Name for Turtle 1
   set space-type 2                      ;; Turtle 1's Space Number
   set happy? false                      ;; which made turtle 1 move from its
                                              Initial placement
   set space-like [1 4 6 7 8 10 ]        ;; list of turtle 1 space number
                                              which this turtle like
   set space-dislike [ 9 ]               ;; list of turtle 1 space number
                                              which this turtle dislikes
 ]                                       ;; end of turtle 0 command
```

The following work-flow was made to summarise the procedure that Netlogo operated in within this first initial model of segregation:

- Turtles were randomly placed within the Netlogo world
- They were commanded to randomly move on every '*ticks*' [34]
- If a turtle moved to a place that happened to be next to one that it liked, it would halt and become stationary.
- If a turtle moved to a place that happened to be next to one that it disliked, it would move in the opposite direction.

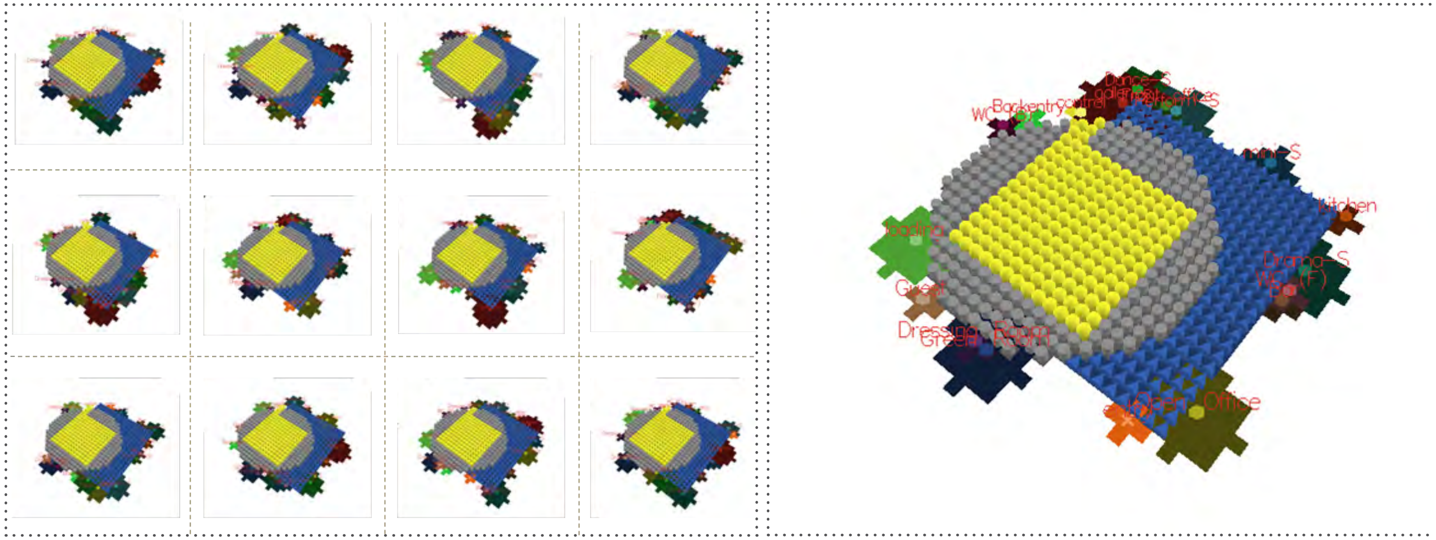
34 Ticks - Time passes in discrete steps within Netlogo Program

T.A.P.A.C Substitution

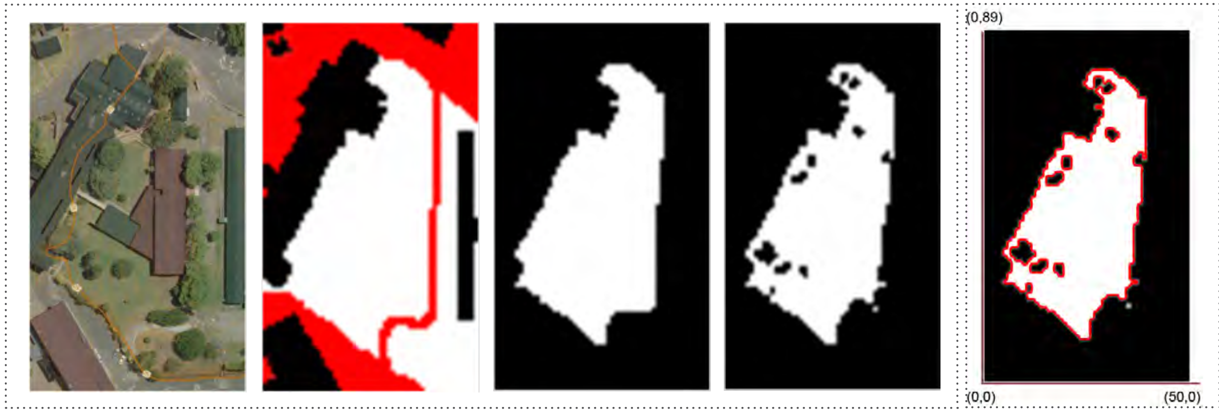
As an initial test to prove whether or not the script that I have created functions correctly, we have substituted the variable of a single storey existing PAC, in this case, T.A.P.A.C, one of the case study buildings. We purposely fixed the three major spaces down as it not only solves the problem we encountered from the primitive script but it also arranges and limits the movements of the minor spaces. Later the computer calculates the possible connection between spaces by following an identical work-flow to that described previously.

At this point, we have searched and run tests to determine whether or not there is a possibility of similarity between the existing T.A.P.A.C floor plan and the arrangement given from the script.

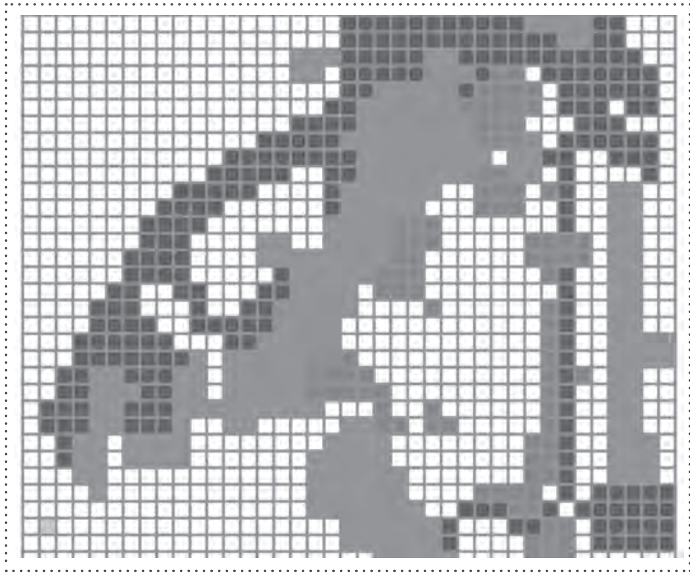
After twelve trials within the virtual world, we found that trial number six shows similarity to the existing T.A.P.A.C. Therefore, this shows that the possibility of space arrangement thought by the architect is also a valid result from the script. Nevertheless, the differences from the script that has generated twelve valid results were caused by twelve manual clicks on the mouse. This shows that the architect has the power to explore the valid possibilities and to ensure that he has made the best choice.



12 Trials (Left) - 1 Choosen to be similar to the existing T.A.P.A.C (Right)



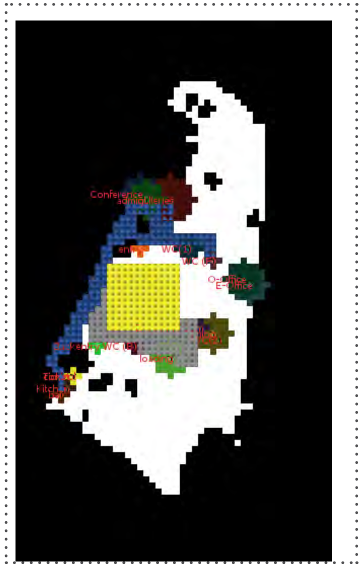
Pixelating the Unitec Site



Development Of Script And Introduction Of Site Boundary

As foreseen the future in the early segregation simulation, the further development of the script was made. As the next step of the development of the script is then introduced with the 'real world' site, the movements of each turtle were now limited to boundary which referenced back to the existing real-world boundary. This generated a virtual site representation, similar to the 'real world' site. At this moment the complexity of scripting becomes harder and more complex due to the increasing numbers of issues, such as the problems with which colour coated patch, the turtles are constrained, and the reactions as they are asked to perform the moment it come in contact with nearby coloured patches. A solution was to insert a script of commands giving turtles a set of action and reaction during each trial circumstances.

Another obstacle was how we would translate and map the real world site plan into the virtual Netlogo 'cells' data. Finally, this was resolved by using an external programme called Photoshop. The trick is to convert the real-world satellite photo into a pixelated image, which can later be imported back into Netlogo's world as 'patches' and cells coordination. Within the script, Netlogo is given an understanding of how approximately the real world site would be:



```
to setup                    ;; When we click button "SETUP"
   ca                       ;; Clear all agents in Netlogo's world
   site                     ;; Run command "site"
 end                        ;; end of command


to site                                              ;; command "site"
   import-pcolors "Blank site - Copy.png"            ;; import image file
                                                       Blank site - Copy.png
end                                                  ;; end of command
```

This not only saved some time, but also provided more accuracy than Netlogo's coordinate mapping. At this stage, we also aim to give each turtle a boundary to provide them a real space area in relation to its site, i.e the turtle named *"Theatre"* may require more boundary limit in relation to the turtle *"w.c"* . The bottom-left image also shows the size of each turtle's radius- all defined by the slider. Thus, if an architect needs to suddenly change a space area for a particular turtle, he may change it on the slider, according to the space area.

```
to-report right-distance?
       report any? other turtles with [distance myself = (my-radius +
       [ my-radius] of myself)]
end
```

Within this development of script, not only do we introduce the script to a site variation but also expend and include more agents. By doing so, we could start studying the impact one turtle has on another. Increasing space agents from six to twenty-one turtles could represent each spatial property. I have chosen the following spaces and tables as such:

#TEST 02	No.	Qty	2 X 2 pixels	Like	Dislike
ENTRY MARKER	1	*1 OR 2*	1	**2**,3,12	4 5 6 7 8 9 10 11 13 14 15 16 17 18 19 20 21
LOBBY	2	*1*	14	**1,3,8,9,10,11, 12,16**,4,5,7	13 14 15 17 18 19 20 21
GALLERIES	3	*1*	42	**2,5**,6,19,1	4 7 8 9 10 11 12 13 14 15 16 17 18 20 21

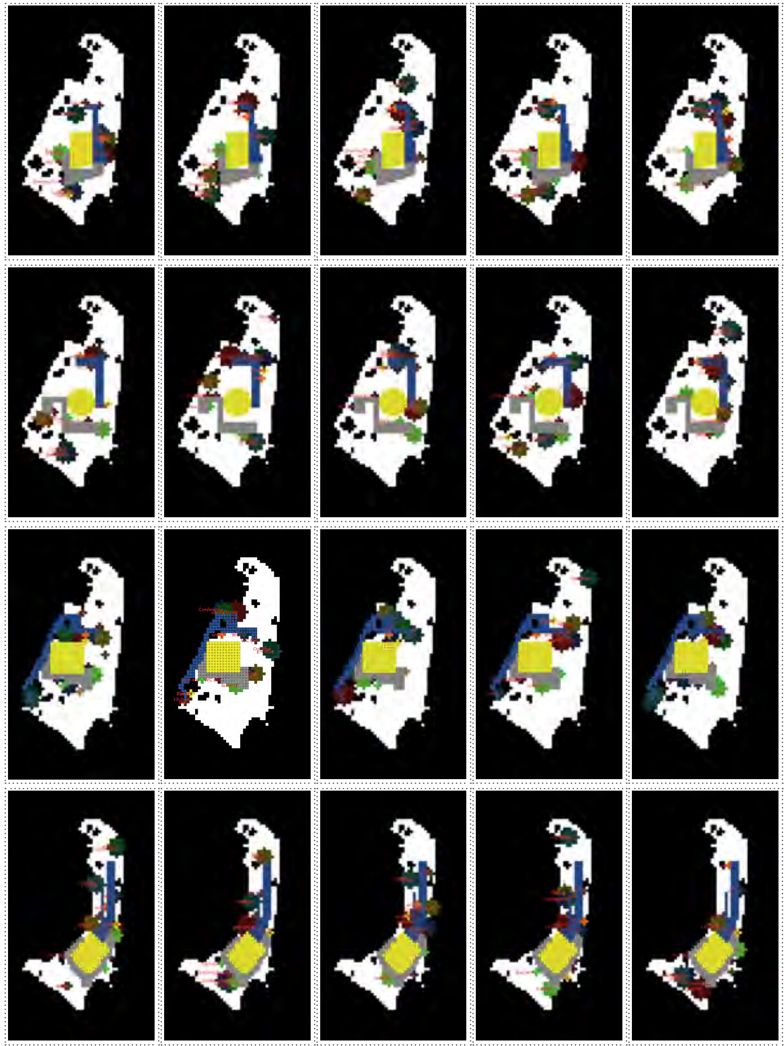
KITCHEN	4	*1*	5	**2**,5,7,13,19	1 3 6 8 9 10 11 12 14 15 16 17 18 20 21
BAR	5	1	3	**2**, 4,16 ,3,7,12	1 6 8 9 10 11 13 14 15 17 18 19 20 21
OPEN OFFICE	6	*1*	25	**7,21** ,2,20	1 3 4 5 8 9 10 11 12 13 14 15 16 17 18 19 21
FRONT OFFICE	7	*1*	1	**2,6,12,21**, 8,9,10,11, 4,5	1 3 13 14 15 16 17 18 19 20
DANCE STUDIO	8	*2*	31	**2,** 7,16	1 3 4 5 6 9 10 11 12 13 14 15 17 18 19 20 21
DRAMA STUDIO	9	*3*	24	**2,** 7,16	1 3 4 5 6 8 10 11 12 13 14 15 17 18 19 20 21
PERFORM STUDIO	10	*2*	31	**2,** 7,16,19	1 3 4 5 6 8 9 11 12 13 14 15 17 18 20 21
MINI STUDIO	11	*1*	10	**2,** 7,16	1 3 4 5 6 8 10 12 13 14 15 17 18 19 20 21
MAIN THEATRE	12	*1*	196	**2,21,** 7,13,14,19	1 3 4 5 6 8 9 10 11 15 16 17 18 20
GREENROOM	13	*1*	25	**12,17**, 14,15, 20	1 2 3 4 5 6 7 8 9 10 11 16 18 19 21
DRESSING ROOM	14	*2*	6	**21,** 13,15	1 2 3 4 5 6 7 8 9 10 11 12 16 17 18 19 20
WC (PERFORMER)	15	*4*	7	**21,** 13,14	1 2 3 4 5 6 7 8 9 10 11 12 16 17 18 19 20
WC (PUBLIC)	16	*2*	7	**2**, 8,9,10,11 , 5	1 3 4 6 7 12 13 14 15 17 18 19 20 21
GUEST ROOM	17	*2*	4	**21,** 13	1 2 3 4 5 6 7 8 9 10 11 12 14 15 16 18 19 20
CONTROL ROOM	18	*1*	3	**12**, 21	1 2 3 4 5 6 7 8 9 10 11 13 14 15 16 17 19 20
LOADING BAY	19	*1*	14	**21**, 3,4	1 2 5 6 7 8 9 10 11 12 13 14 15 16 17 18 20
BACK ENTRY	20	*1*	1	**21**, 13	1 2 3 4 5 6 7 8 9 10 11 12 14 15 16 17 18 19
MAIN BACKSTAGE	21	*1*	105	**12, 14, 15, 17, 19, 20,** 18	1 2 3 4 5 6 7 8 9 10 11 13 16

Final Result Evaluation

As the result data is collected from the case studies to inform the algorithm tests until we got one that we liked, the architect now has a better understanding of the spatial arrangement in relation to its site, which results in better judgement of an architectural spatial configuration. Once we got to a point that worked for the case studies, we then applied the results to the those of Unitec as it is faster and provides less dilemma regarding the resources by using the traditional "Massing models for spatial studies".

As shown in the next page, twenty valid results are listed. As of this moment, the designer would need to choose subjectively and logically by filtering. The filtering method is settled upon as it raises judgemental questions that would reduce the poor results. The first major filtering method I would use is whether it is possible for the turtle called ***"entry"*** to be accessible from the road, followed by whether the spaces around it make logical sense.

First within this Unitec PAC project, it is ideal to subjectively select the best front and rear entrance to meet the criteria of the general rule in designing a PAC (must have separate entry between stage and audience). The second is whether the audience entry be closer to Gate One entry and the ***'Back entry'*** located closer to the Gate Two entry. The architect can later subjectively filter the overall aesthetic form. These results will be repeatedly questioned and filtered until three promising spatial arrangements are made. These images show how the data that was collected from the Netlogo model could be translated into rough floor plans.



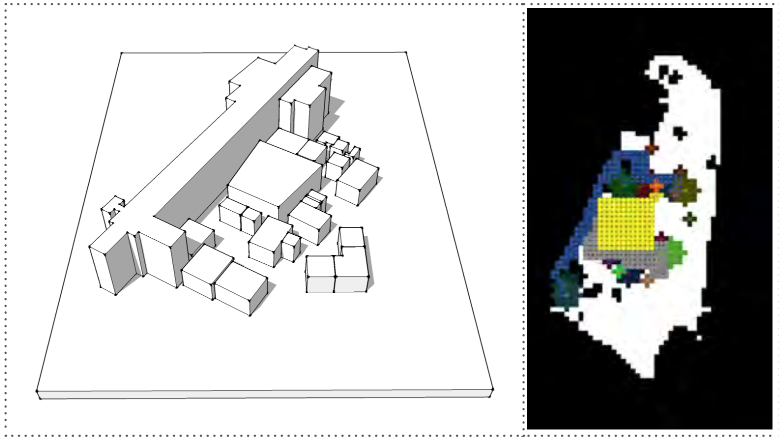
20 Results given from the Netlogo

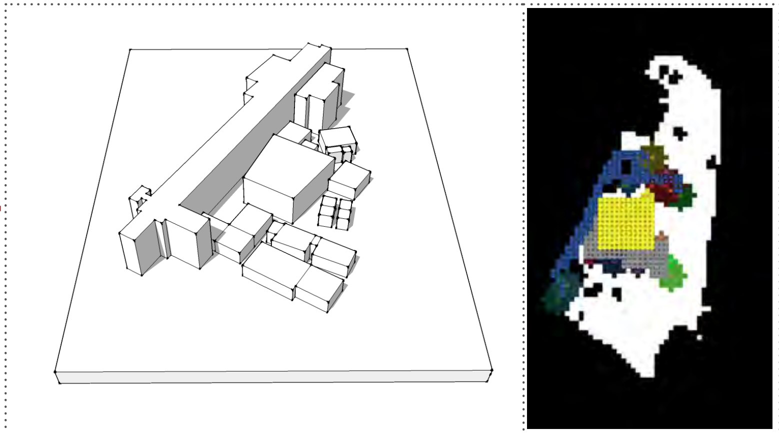
Critique the results by:

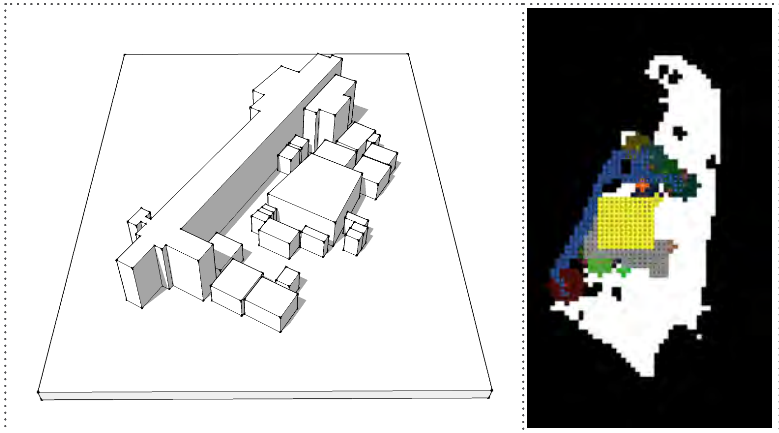
- *Aesthetic / Material*
- *Anticipate forms*
- *Journey*
- *Relationship to the existing building*
- *Sustainability*
- *Anticipate structure*

Critique and Filter

Three Most Potential Candidates







Potential Further Improvement

The script models we have created explore and examine the possibilities for the architect to use as a tool. Therefore, the arrangement of the space of the model itself will not be considered as a final perfect layout. Currently, these models are best for arranging designs which have lesser categories of space. Circulation within a Performance Art Centre design is crucial, therefore, with PAC complex circulation, data collected from this primitive script model may not necessary be a successful example, but it might possibly work in a case such as a hotel or apartment design. Thus, within a hotel or apartment design, repetition of ideal space may often occur. Therefore, a new set of rules for individual spaces (agents/ turtles) are needed to be re-defined, resulting in spatial areas that are less constrained, and less complex.

There are things which can be further pushed in Netlogo, as 3D images could be shown visually for the audience to understand with fewer complications as transitions and openings to each space are clearer to analyse. The future model may also be introduced in the 3D format, and 3D world space containing X, Y, Z axes.

Re-examining each turtle's command at this moment would very likely give a much more definite result as the computer cannot define the exact requirements due to the different sizes of each space. Each time a turtle finds another it likes, the two settle down together. More than two turtles can settle down together, however, if one turtle that the others do not like comes along and joins the settled ones, the entire group will disperse. This process may repeat over long periods of time and, as a result, time may be consumed without any tangible result.

Conclusion

Theory behind this Experiment

Within the time limits of this project, a method has been developed that underlies my concepts to enhance further algorithmic architecture research. As Netlogo has undergone a series of simulations for the urban environment, it also has the potential to evaluate and simulate much smaller contexts such as architectural spaces or layout. To summarise the procedure, I would first do a site analysis of the Unitec theatre. This includes vital information, such as the hierarchy of space, ranging from *'must be together'* to *'must not be together'.* Once a clear picture is established of what is required for individual spaces and site variables, it is possible to alter the script to fit. In trying to evaluate the computer results it is senseless to accept only one valid solution. Therefore, to apply the algorithmic model as a useful tool, fifteen or more results are required. From such a choice architects can then perform a subjective evaluation to determine the three best possible layouts, whilst taking into consideration sustainability, structure and economic aspects. No matter whether a template will be used, or later developed, the architect must have a conscious image of a possible way of putting the layout together. This is a valid way to optimise the design process as it provides a faster solution for the architect to understand the Site versus Space relationship.

Promising Future?

To conclude, the answer is *yes.* After researching how spaces in popular Auckland performance art centres are arranged and converted into data, the key study of the spatial assembly has been proven to work, as each space has its own hierarchy due to its unique site. The logic behind the computer program has also been proven to be very fast and flexible to moderate the model as a pattern of data, as established from the case studies. Possibilities of widening the vision of an architect by providing a number of valid solutions, which may later be used as a design template for the architect, have also been investigated to create useful models for the Unitec theatre. Furthermore, *human decisions* are applied as aesthetic as this gives the building a soul, rather than being entirely *computer-driven*. In conclusion, while this project is too complex for the computer, it does provide objective clarity to the spatial-site-relationship.

However, certain obstacles became an issue in expanding this algorithmic model. With more time this experiment has a promising future, but time constraints only allowed a measure of proof. People with high level skills and experience in this field were not available to me during the project, which limited my resources and therefore ability (along with time) to see this project to the completion I envisaged. Funding was also not established, which resulted in budget constraints as I could not afford to hire a computer programmer, nor is there the option of buying a similar script off the shelf due to the novel nature of the design principle.

Because of these limitations, it is valuable to step back and reflect on the case studies once more. Relating back to the field that I created earlier on from the three case studies, I came to the realisation that I had no choice but to design my current project using the old, analogue, and methods. However, the results that I have gathered from the computer aided work have very much inspired my designs and foresaw the possible outcomes that would not have happened if I had worked entirely in a traditional manner.

Professional Critique To Segregation Model

How to judge it?

As I am not entitled to be an architect or PAC designer yet, I have no choice but to ask for guidance from theatre professionals.. One of the directors that supported me was Paul Minifie of the Maidment Theatre Centre from the University of Auckland. Minifie believed that the possibility of this digital generated space and its spatial results could only be used as a *"primitive template"* for an architect. It is not ideal to be used as the final space for a PAC, but there are opportunities where the architect has the freedom to develop and express his creativity. In light of this, it lacks crucial information such as the space connections, the circulation space, the space opening and also PAC uniqueness. Minifie also mentioned that there is a risk that the architect could be pressured, thus limiting his creativity in the earliest stages, which could result in a less interesting and, possibly, insignificant architectural design.

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Appendix A
Script

```
globals
[ percent-like
  percent-unhappy]
turtles-own
[  happy?
  space-type
  space-must                                    ;new
  space-like-50                                 ;new
  space-like-25                                 ;new
  space-dislike                                 ;new
  must-nearby                                   ;new
  like-nearby-50                                ;new
  like-nearby-25                                ;new
  dislike-nearby
  total-nearby
  patch-there
  my-radius]                                    ;;; add on

to setup
  ca
 site
 kura
end

to site
;  import-pcolors "Blank site.png"
import-pcolors "TAPAC experiment1.png"
;  import-pcolors "Site 01.png"
;  import-pcolors "Site 02.png"
;  import-pcolors "Site 03.png"
;  import-pcolors "Site 01 - Concept 1.png"
;  import-pcolors "Site 01 - Concept 2.png"
;  import-pcolors "Site 01 - Concept 3.png"
;  import-pcolors "Site 01 - Concept 4.png"
end

to clear-site
clear-turtles
```

```
kura
end

to kura
  n-of 18 patches with[ pcolor != black ]                ; we have 21 spaces now
 [ sprout 1
  [ set shape "square"
   set color blue
   set label-color red ]
  ]

ask turtle 0
 [ set label "entry"
   set space-type 1
   set happy? false
   set space-must [ 2 ]                    ; write the same for every space-type i.e. ask turtle 1.....
   set space-like-50 []                    ; empty list lobby doesn't have any space-like-50
   set  space-like-25 [3 12]
   set space-dislike [ 1 4 5 6 7 8 9 10 11 13 14 15 16 17 18 19 20 21]
   set size 1
   set shape "x"
   set my-radius 1                         ;; slider
   set color 26.5
 ]

  ask turtle 1
 [ set label "galleries"
   set space-type 3
   set happy? false
   set space-must [ 2 5 ]                  ; write the same for every space-type i.e. ask turtle 1.....
   set space-like-50 [2]                   ; empty list lobby doesn't have any space-like-50
   set  space-like-25 [6 19 1]
   set space-dislike [ 4 7 8 9 10 11 12 13 14 15 16 17 18 20 21]
   set size 1
   set shape "box"
   set my-radius Galleries-radius
   set color 13.5
 ]

  ask turtle 2
 [ set label "kitchen"
   set space-type 4
```

```
set happy? false
set space-must [ 2 ]                                  ; write the same for every space-type i.e. ask turtle 1.....
set space-like-50 [ 5 ]                               ; empty list lobby doesn't have any space-like-50
set  space-like-25 [ 7 13 19 ]
set space-dislike [ 1 3  6 8 9 10 11 12 14 15 16 17 18 20 21]
set size 1
set shape "box"
set my-radius kitchen-radius
set color 23.5
]

ask turtle 3
[ set label "Bar"
set space-type 5
set happy? false
set space-must [ 2 ]                                  ; write the same for every space-type i.e. ask turtle 1.....
set space-like-50 [ 4 16 ]                            ; empty list lobby doesn't have any space-like-50
set  space-like-25 [ 3 7 12 ]
set space-dislike [ 1 3 5 6 8 9 10 11 13 14 15 17 18 19 20 21]
set size 1
set shape "box"
set my-radius bar-radius
set color 33.5
]

ask turtle 4
[ set label "Open Office"
set space-type 6
set happy? false
set space-must [ 2 ]                                  ; write the same for every space-type i.e. ask turtle 1.....
set space-like-50 [7]                                 ; empty list lobby doesn't have any space-like-50
set  space-like-25 [ 20 21]
set space-dislike [ 1 3 4 5 8 9 10 11 12 13 14 15 16 17 18 19]
set size 1
set shape "box"
set my-radius openoffice-radius
set color 43.5
]

ask turtle 5
[ set label "Front office"
set space-type 7
```

```
set happy? false
set space-must [ 2 6 ]                          ; write the same for every space-type i.e. ask turtle 1.....
set space-like-50 [ 8 9 10 11  12]              ; empty list lobby doesn't have any space-like-50
set  space-like-25 [ 4 5 21]
set space-dislike [ 1 3 13 14 15 16 17 18 19 20]
set size 1
set shape "box"
set my-radius frontoffice-radius
set color 53.5
]

ask turtle 6
[ set label "Dance-S"
set space-type 8
set happy? false
set space-must [ 2 ]                            ; write the same for every space-type i.e. ask turtle 1.....
set space-like-50 []                            ; empty list lobby doesn't have any space-like-50
set  space-like-25 [7 16]
set space-dislike [ 1 3 4 5 6 9 10 11 12 13 14 15 17 18 19 20 21]
set size 1
set shape "box"
set my-radius DanceS-radius
set color 63.5
]

ask turtle 7
[ set label "Drama-S"
set space-type 9
set happy? false
set space-must [ 2 ]                            ; write the same for every space-type i.e. ask turtle 1.....
set space-like-50 []                            ; empty list lobby doesn't have any space-like-50
set  space-like-25 [7 16]
set space-dislike [ 1 3 4 5 6 8 10 11 12 13 14 15 17 18 19 20 21]
set size 1
set shape "box"
set my-radius Dramas-radius
set color 73.5
]

ask turtle 8
[ set label "Perform-S"
set space-type 10
```

```
set happy? false
set space-must [ 2 ]                      ; write the same for every space-type i.e. ask turtle 1.....
set space-like-50 []                      ; empty list lobby doesn't have any space-like-50
set  space-like-25 [7 16 19]
set space-dislike [ 1 3 4 5 6 8 9 11 12 13 14 15 17 18 20 21]
set size 1
set shape "box"
set my-radius performanceS-radius
set color 83.5
]

ask turtle 9
[ set label "mini-S"
set space-type 11
set happy? false
set space-must [ 2 ]                      ; write the same for every space-type i.e. ask turtle 1.....
set space-like-50 []                      ; empty list lobby doesn't have any space-like-50
set  space-like-25 [7 16]
set space-dislike [ 1 3 4 5 6 8 9 10 12 13 14 15 17 18 19 20 21]
set size 1
set shape "box"
set my-radius miniS-radius
set color 93.5
]

ask turtle 10
[ set label "Green Room"
set space-type 13
set happy? false
set space-must [ 12 17 21]                ; write the same for every space-type i.e. ask turtle 1.....
set space-like-50 [14 15]                 ; empty list lobby doesn't have any space-like-50
set  space-like-25 [20]
set space-dislike [ 1 2 3 4 5 6 7 8 9 10 11 16 18 19]
set size 1
set shape "box"
set my-radius GreenR-radius
set color 103.5
]

ask turtle 11
[ set label "Dressing Room"
set space-type 14
```

```
 set happy? false
 set space-must [ 21 ]                    ; write the same for every space-type i.e. ask turtle 1.....
 set space-like-50 []                     ; empty list lobby doesn't have any space-like-50
 set  space-like-25 [13 15]
 set space-dislike [ 1 2 3 4 5 6 7 8 9 10 11 12 16 17 18 19 20]
 set size 1
 set shape "box"
 set my-radius DressingR-radius
 set color 113.5
 ]

 ask turtle 12
[ set label "WC (B)"
 set space-type 15
 set happy? false
 set space-must [ 21 ]                    ; write the same for every space-type i.e. ask turtle 1.....
 set space-like-50 []                     ; empty list lobby doesn't have any space-like-50
 set  space-like-25 [13 14]
 set space-dislike [ 1 2 3 4 5 6 7 8 9 10 11 12 16 17 18 19 20]
 set size 1
 set shape "box"
 set my-radius WC-Back-radius
 set color 123.5
 ]

 ask turtle 13
[ set label "WC (F)"
 set space-type 16
 set happy? false
 set space-must [ 2 ]                     ; write the same for every space-type i.e. ask turtle 1.....
 set space-like-50 [ 8 9 10 11]           ; empty list lobby doesn't have any space-like-50
 set  space-like-25 [5]
 set space-dislike [ 1 3 4 5 6 7 12 13 14 15 17 18 19 20 21]
 set size 1
 set shape "box"
 set my-radius wc-front-radius
 set color 133.5
 ]

 ask turtle 14
[ set label "Guest"
 set space-type 17
```

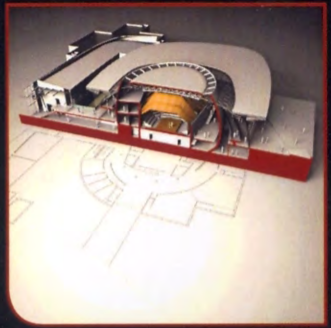
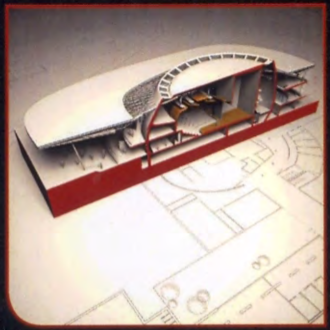
```
set happy? false
set space-must [ 21 ]                ; write the same for every space-type i.e. ask turtle 1.....
set space-like-50 []                 ; empty list lobby doesn't have any space-like-50
set  space-like-25 [13]
set space-dislike [ 1 2 3 4 5 6 7 8 9 10 11 12 14 15 16 18 19 20]
set size 1
set shape "box"
set my-radius guestR-radius
set color 36.5
]

ask turtle 15
[ set label "control"
set space-type 18
set happy? false
set space-must [ 12 ]                ; write the same for every space-type i.e. ask turtle 1.....
set space-like-50 [21]               ; empty list lobby doesn't have any space-like-50
set  space-like-25 []
set space-dislike [ 1 2 3 4 5 6 7 8 9 10 11 13 14 15 16 17 19 20]
set size 1
set shape "box"
set my-radius controlr-radius
set color 46.5
]

ask turtle 16
[ set label "loading"
set space-type 19
set happy? false
set space-must [21]                  ; write the same for every space-type i.e. ask turtle 1.....
set space-like-50 []                 ; empty list lobby doesn't have any space-like-50
set  space-like-25 [3 4]
set space-dislike [ 1 2 5 6 7 8 9 10 11 12 13 14 15 16 17 18 20 ]
set size 1
set shape "box"
set my-radius loadingbay-radius
set color 56.5
]

ask turtle 17
[ set label "Backentry"
set space-type 20
```

```
    set happy? false
    set space-must [21]                                   ; write the same for every space-type i.e. ask turtle 1.....
    set space-like-50 []                                  ; empty list lobby doesn't have any space-like-50
    set  space-like-25 [13]
    set space-dislike [ 1 2 3 4 5 6 7 8 9 10 11 12 14 15 16 17 18 19]
    set size 1
    set shape "x"
    set my-radius 1
    set color 66.5
  ]
end

to draw-maintheater
  if mouse-down?
   [ ask patch mouse-xcor mouse-ycor
     [ set pcolor red ]
   ]
end

 to make-turtles-maintheater
  ask patches with [ pcolor = red ]
   [ sprout 1
     [set shape "square 2"
      set color yellow
      set label-color red
     set pcolor white
    set space-type 12
    set happy? true
    set space-must [ 2 21 ]                               ; write the same for every space-type i.e. ask turtle 1.....
    set space-like-50 []                                  ; empty list lobby doesn't have any space-like-50
    set  space-like-25 [7 13 14 19]
    set space-dislike [ 1 3 4 5 6 8 9 10 11 15 16 17 18 20]
    set size 1
    set shape "circle"
    set my-radius maintheater-radius
    set color yellow]
  ]
end

to draw-lobby
  if mouse-down?
   [ ask patch mouse-xcor mouse-ycor
```

```
      [ set pcolor green ]
    ]
  end

  to make-turtles-lobby
    ask patches with [ pcolor = green ]
    [ sprout 1
      [;set label "lobby"
        set pcolor white
     set space-type 2
     set happy? true
     set space-must [ 1 3 8 9 10 11 12 16 ]          ; write the same for every space-type i.e. ask turtle 1.....
     set space-like-50 []                            ; empty list lobby doesn't have any space-like-50
     set  space-like-25 [4 5 7]
     set space-dislike [ 6 13 14 15 17 18 19 20 21]
     set size 1
     set shape "triangle"
     set my-radius lobby-radius
     set color blue]
      ]
     end

  to draw-backstage
    if mouse-down?
     [ ask patch mouse-xcor mouse-ycor
        [ set pcolor yellow ]
     ]
  end

  to make-turtles-backstage
    ask patches with [ pcolor = yellow ]
    [ sprout 1
      [set space-type 21
        set pcolor white
     set happy? true
     set space-must [12 14 15 17 19 20]              ; write the same for every space-type i.e. ask turtle 1.....
     set space-like-50 [18]                          ; empty list lobby doesn't have any space-like-50
     set  space-like-25 []
     set space-dislike [ 1 2 3 4 5 6 7 8 9 10 11 13 16 19 ]
     set size 1
     set shape "cylinder"
     set my-radius Backstage-radius
```

```
    set color grey]
  ]
  end

to go
  if all? turtles [happy?]
   [ ask turtles [set heading 0
      ask patches in-radius my-radius [ set pcolor [color] of myself - 2]
      stop]]                                             ;before stop put
      move-unhappy-turtles
      ask turtles with [not happy?][ update-turtles-two]
end

to update-turtles-two
    set must-nearby count (turtles-on neighbors) with [ member? space-type ([space-must] of myself ) ]
    set like-nearby-50 count (turtles-on neighbors) with [ member? space-type ([space-like-50] of myself) ]
    set like-nearby-25 count (turtles-on neighbors) with  [ member? space-type ([space-like-25] of myself) ]
    set dislike-nearby count (turtles-on neighbors)  with [ member? space-type ([space-dislike] of myself) ]
    set total-nearby  (must-nearby + like-nearby-50 + like-nearby-25 + dislike-nearby)
    if must-nearby > 0 and dislike-nearby = 0 and  (must-nearby + like-nearby-50 + like-nearby-25 >= %-similar-wanted *
total-nearby / 100 )  [ set happy? true]
end

to move-unhappy-turtles
 ask turtles with [ not happy? ]
   [ find-new-spot ]
end

to find-new-spot
 set patch-there patch-at-heading-and-distance random-float 360 random-float 5
 ifelse [pcolor] of patch-there != black
[ move-to patch-there
 if any? other turtles-here [find-new-spot]
 move-to patch-here ]
[find-new-spot]
end

to-report right-distance?
 report any? other turtles with [distance myself = (my-radius + [ my-radius] of myself)]
end
```

END



AUCKLAND
01
Highlight of Project + Research
02
Basement + Floor Plan
03
Ground + Floor Plan
04
1st Floor Plan
05
06
Inside the Theatre
07
Event Lighting
08
09
10
Sequence of Spaces