URBAN MORPHOLOGY INCORPORATING COMPLEXITY AND VARIATION

A STUDY IN THE USE OF PARAMETRIC URBAN MODELLING TECHNIQUES IN JINGDEZHEN, CHINA

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The rapid rate of urbanisation (Burdett, Kanai, 2006) today has resulted in extreme changes to the physical fabric of many cities with the only constant being the increasing rate of change. In developing parts of the world urban territories undergoing constant, sudden and drastic changes in topology due to market led planning and gentrification compete with the speed of rapidly growing informal urban settlements. The failure of most current urban planning and design tools are primarily an inability to address processes of change over time and a powerlessness to genuinely incorporate bottom up and emergent urban processes. How does one design for the unplanned? How does one attempt to influence constant change? This is a short introduction to a number of temporal design tools that were developed in an attempt to incorporate complex behaviour into the design of morphological urban territories.

SCOPE AND PARAMETERS

> Unit 6, a post-graduate design unit from the University of Nottingham, Department of Architecture and the Built Environment, carried out a remote urban and historic study, as well as on site visual street level studies of the city of Jingdezhen. The aim was to develop post-graduate thesis projects and, contribute through critical discourse to the city's proposed five year plan, which aims to promote urban growth via an attempt to re-invent the city as a cultural centre based upon its historical position as the 'Ceramic Capital of China'.

1. Jingdezhen Urban Topography

< The initial studies were into the historic growth of Jingdezhen and the current economic policies resulting in competition between cities in China in the form of an urban race to encourage urban growth and thus attract external investment. The second part of the study concentrated on site, street level studies, to find both specific and collective identifiable urban phenomena in Jingdezhen. These bottom-up social, economic and spatial indicators were categorised in order to formulate a body of information that could be used to inform, influence and question the proposed macro-level approaches to urban development adopted by the city.

< The city had already carried out several studies prior to development proposals, and these included data in the direction of identified existing and historic sites of interest for the purpose of their re-branding (Kavaratzis, Ashworth, 2005) exercise. Based on our site studies, we identified many layers of the city that could be considered to be of cultural and social value and have attempted to point out some of the less obvious but no less interesting aspects that exist within the city and contribute to its identity (Proshansky, 1978). The phenomena identified were both negative and positive indicators, but through recognition and incorporation, could be used positively to contribute significantly to the vibrancy and plurality that are important aspects for the sustainable urban growth of Jingdezhen.

2-5. Street Scenes from the Porcelain City

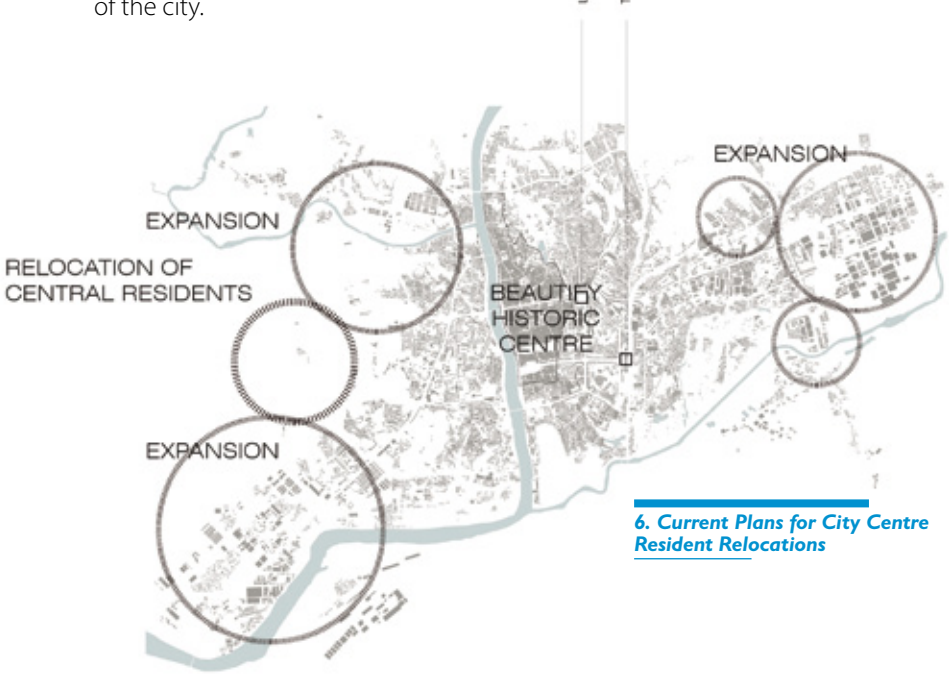
CURRENT APPROACH AND AMBITIONS (EXISTING DEVELOPMENT PLANS AND CRITIQUE)

> The city of Jingdezhen is currently competing to be one of the fastest growing urban centres within the Jiangxi province. As with other urban conglomerations in China today, the possible economic benefits for the city are intrinsically tied to the demand for real estate and the ability to attract external investment through tourism, new industry and attractive residential lifestyles. Jingdezhen has a unique historical background as it was the most important location for the production of porcelain in China, and the location of the Imperial Kilns. This fact and its ongoing recognition throughout China as the 'Porcelain City' is currently being used as the cornerstone of a branding and urban regeneration exercise. There is a 5 year plan in place (2010-2014) and a number of strategic approaches have been identified including expansion, re-use, regeneration, infrastructure and industry.

> Given the seemingly unwavering aim of the city to pursue its ambitions for accelerated urban growth, as part of the current wave of urbanisation in China, with most cities of a similar or larger size hoping or attempting to do the same, some of the current strategies have been examined below with a critical view towards their effectiveness, long term sustainability and their resultant socio-spatial effects on the existing and expected urban population.

> Planned Ambitions (City Planning & Regulatory Bodies, 2010) – Summary of current city strategy:

- Use the historic importance/name of the city to create recognition at an international level.
- Plan new events and centres to rejuvenate the porcelain production and associated identity of the city.
- Shift the existing porcelain industry from a primarily mass production base to a creative one.
- Consider the re-use and preservation of existing historic sites.
- Attempt to attract international ceramic artists as residents through the creation of specialist arts villages.
- Encourage independent innovation enterprises as opposed to state controlled ventures.
- New hi-tech industries to be actively courted with new infrastructure aimed towards this purpose along the eastern and south-western edges of the city.
- Ambition to host the most prestigious international artistic/creative ceramic awards on an annual basis.
- Planned investment in new cultural centres (New Ceramic expo-centre already built).
- Expansion of the service industry & visitor attractions through the introduction of more commercial and retail parks within the city.
- Protection of recognised historic relics, buildings and neighbourhoods (connected to the existing/remaining kilns and imperial monuments, but neighbourhoods undefined as yet).
- Plan to establish an international ceramic trading zone within the city centre.
- Cleaning up of the city centre through the removal of the majority of historic, informal and unplanned structures and relocation of the majority of this resident population in new subsidised housing on the western edge of the city.
- Beautification of retained city centre fabric through façade replacement and stylised façade additions based on historic building types.



6. Current Plans for City Centre Resident Relocations

CRITICAL CHALLENGES

> There are concerns, with regards to the longer term social and environmental sustainability, with the adopted approaches of large scale urban real estate re-distribution and encouraged greenfield development. If the plans are not critically re-appraised, they would have negative effects in terms of displacement of the local population, gentrification and enforced exclusion of large parts of the existing population. The possibilities of disneyfication (Zukin, 1996) as a direct result of attempts to base the strategy of urban regeneration on a rebranding of the currently declining porcelain industry (due to economic competition on mass produced products and the economic downturn affecting the construction industry), also poses severe challenges in terms of increasing the socio-economic benefits for the residents of the city. Critical issues are:

- The specialist arts villages are planned outside the city centre due to the availability of land and perception of an 'ideal' artists' village environment. This creates the requirement for additional travel and transport, while displacing the industry itself from the existing residents.
- There is a lack of any plan to integrate the river and waterways into the regeneration of the city despite its potential as a sustainable transport system and leisure/ecological zone.
- Unsustainable long term planning in terms of local resident relocation and re-housing away from the historic city centre.
- Insufficient enthusiasm for ecological issues despite the recognition of its value to human habitat. Urban lifestyles and ecological issues could be prioritised to enhance 'green' conditions and desirable 'quality of life'.
- High speed of planned city expansion and urban renewal has inherent dangers and adequate feedback mechanisms need to be put in place to ensure that policy and actual change on the ground are concurrent.
- Dangers of 'Disneyfication' rather than an actual living and breathing city identity should be carefully considered at all times.
- Undefined approach to ecology and no recognition of existing ecological features can lead to the loss of these resources through development.
- Lack of tools to design informal settlements leading to homogeneous planned housing schemes.
- Ongoing development during study (5 years) of the existing context has resulted inevitably in the inaccuracy of the recorded context, resulting in outdated information even before proposals are formulated.
- The future proposals prepared by the city establish a fixed goal to work towards, thus creating a situation that cannot incorporate change during the process.

The spatial strategies above are based on formalising all future urban development, maximising the use of easily available city edge green field sites and erasure of perceived negative conditions within the city (primarily referring to the informal historic sector that constitutes the majority of the existing city centre). These strategies are being pursued in order to beautify the city, re-brand it and thus attract new investment in land and hi-tech industries. The current plans clearly run the danger of segregating social groups through spatial displacement, creating homogeneous tower block dominated zones on the peripheries and gentrifying the city centre to the point of creating landscapes of exclusion (Pow, 2009) for the majority of its current residents. While the political drivers themselves are complicit, it should also be recognised that the failure of this proposal lies inevitably with the lack of available tools to plan/design for the reality of urban change today, and to the continued use of approaches that are unable to incorporate change and complexity. <

7. Future City Model (Cartesian Homogeneous Planning)

COMPLEXITY

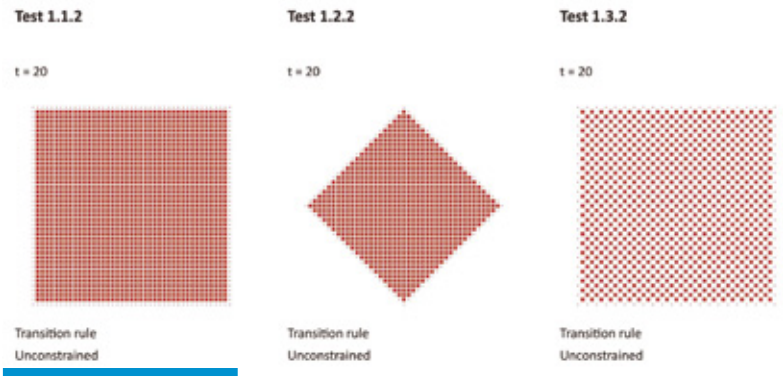
> Complexity Theory, Complex Systems Theory and increasing computational power to visualise complex systems is beginning to challenge prevalent methods of urban design and planning. Cities are made of many interlinked layers of complimentary, contrasting and contradictory fields in which objects, territories and drivers overlap and influence each other in feedback loops. Using the simplistic understanding of Complex Systems Theory in which the whole is bigger than the sum of the parts, and interactions at the local level having indirect and unpredictable results on the whole system, it is easy to see why cities are ideal examples.

> It is common practice within urban planning, urban design and architecture to use reductive techniques of separation in order to both quantify and comprehend layers within existing urban territories, but the ability to recombine these and additional layers into interrelated and yet cognitive systems that can act both as independent fields of interaction within themselves and influence every other layer within the system, over time, has potential that as yet remains largely unexplored. In order to design for complexity, one must take an approach that allows the setting up of a rule and pattern based systems which can evolve over time, avoid the assumption of fixed objects or spaces and allow for changes to the system during the process of evolution itself.

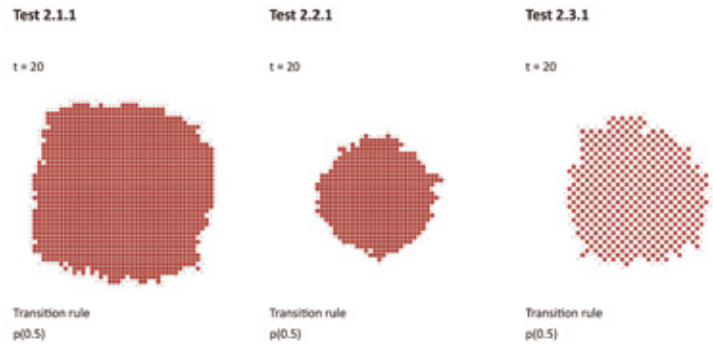
CELLULAR AUTOMATON (MACRO SCALE)

> Cellular Automaton is used here as a study of simulated urban growth processes. The original experiments are based on explorations by Michael Batty (Batty, 2009). They demonstrate how it is possible to create expanding systems across a cellular grid with differing behaviour by changing the transition rules that determine why a particular cell should change to a new state, remain in its current state, or revert to its previous state, depending on the state of its neighbours. Simple rules for local cell interactions can provide controlled geometric expansions (Fig. 8). However, once randomness (in direction) is incorporated into the same system we can see that the growth though almost uniform is actually simulative of a more organic system, where the outcome of an experiment run more than once would provide results slightly different from all previous ones (Fig. 9). As a third stage probability (of change/growth) was added to the system providing a series of useful CA models that resulted in deterministic systems allowing variation and emergence, with differing possible outcomes for each model on every execution, and at each stage (Fig. 10).

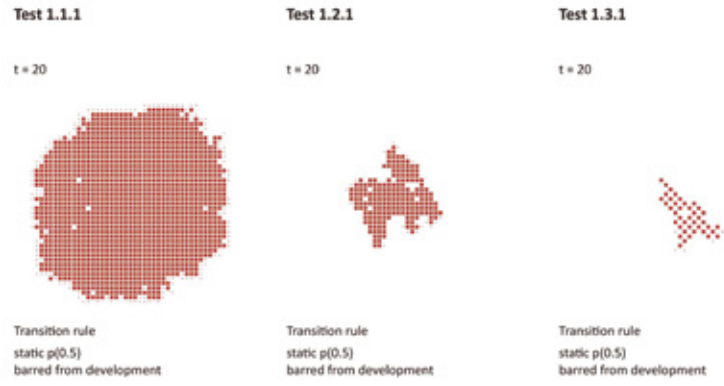
CELLULAR AUTOMATA
Transition Rule experiments



8. CA by fixed rules only



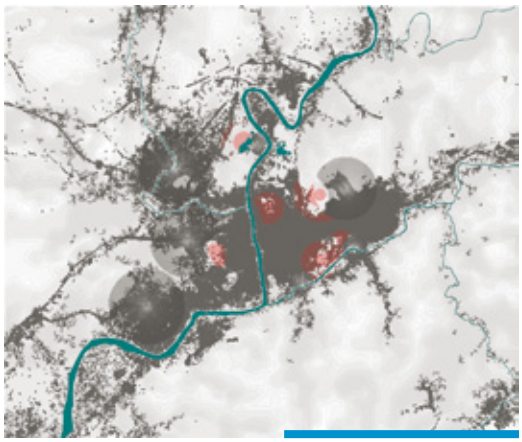
9. CA by fixed rules and random direction



10. CA by fixed, random direction and probability

> The reason we choose to use CA's at this scale instead of an agent based system is best explained with reference to Deleuze and Guattari's comparative descriptions of the games of *Chess* and *Go*[1]. Upon examination of the two games, we can understand significant differences that can be used as an analogy to describe the two systems in terms of their differing possibilities. In Chess hierarchically different pieces move across a gridded territory, sometimes occupying each bounded square space, sometimes able to affect the pieces in the opposing faction and sometimes transforming themselves. While this creates a degree of complexity in terms of the interactions of the pieces themselves, the actual territory or field remains unaffected. In Go however, despite the existence of an underlying grid structure, every single piece is defined in terms of its relationship to other pieces on the board, and every new piece placed on the grid has the potential to change the whole or part of the previously placed pieces which in turn make up the current state of the field. Thus it is possible to reach an understanding of Go as a system in which the pieces actually create a field of dynamic relationships (i.e. a new territory), where the state of the field is constantly re-structured by the introduction of any new piece. For the purposes of the macro scale study, it became apparent that the primary objective would need to be the transformation of the territory (field) itself and hence a CA if sufficiently complex would provide the closest abstracted system for us to study models simulating urban growth.

> It is necessary to recognise that a single CA layer (field) of relations based on simplified rules of growth will not allow for sufficiently complex behaviour due to the lack of environmental and external influences on the system. In order to create a CA simulating uncontrolled and incremental urban growth in a real geo-spatial context, several layers of external information from topography to policy have to be incorporated into the model. It is of absolute importance that each of these layers of information (e.g. height map) are in themselves not static fields, but added to the model in the form of dynamic fields that can influence the CA and be influenced in return (e.g. due to local density of the CA in its current state) through feedback loops (looped algorithms). With the addition of more 'fields' of information (simulating new attractors, infrastructure, zoning, etc), all interlinked with every other field, complex yet influence-able systems capable of simulating incremental urban growth patterns begin to emerge. As an additional degree of complexity, force fields that would change the probability of other layers can be inserted as attractors or detractors (simulating new urban attractions, transport hubs, changes in land regulation or value) on a temporal basis, creating the possibility to interactively change the field through external interruptions.



11. CA with Topographic Values & Inserted Temporal Attractor/Detractor Fields

EMERGENCE (UNAVOIDABLE AND DESIRABLE)

Historically if traced back to their origins the majority of cities can be seen to have occurred through processes of emergence, where the physical manifestations of daily life, property and shelter were defined primarily through boundaries and forms of enclosure that adapted to different environmental and spatial conditions in order to form agglomerations depicting self organisational qualities. All cities today display degrees of <

[1] An excellent description of this reading including illustrations was provided as part of the article titled 'En route: Towards a Discourse on Heterogeneous Space beyond Modernist Space-Time and Post-modernist Social Geography' which has basically been shortened here for our use.

emergence, but the processes of zoning, planning and regulation based on the repetitive gridded parcellation of land has largely denied spectacular scales of emergent urban territories in the developed world[2]. The less regulated and enforced cities of developing countries tend to provide the clearest examples, due to large scale propagation of informal settlements and slums. Governmental authorities interested in formalising urban systems have generally favoured existing models for land use zoning and city planning in order to facilitate growth towards recognisable models and ideas of global cities (Sassen, 1991). However, there continues to be a critique of these processes as they inevitably lead to processes of gentrification that contribute directly to the marginalisation of poorer segments of the populations of cities.

12. Jingdezhen - Result of Control & Formalisation

> It is only in relatively recent developments that there has been recognition of the fact that informal sectors in cities are quite often unavoidable and even provide possibilities and opportunities for the formal system that are both desirable (Roy, 2005) and necessary within the complex socio-economic workings of cities. It is now becoming possible to have conversations about the morphology of cities that can act as a critique on current processes of planning and design based primarily on pre-defined plot ownership and the possibilities of regulation controlled objects built upon repetitive parcels. However, alternative understandings of positive or integral contributions of informal processes within cities have yet to become part of design processes that will allow for the design of inclusive systems allowing emergent qualities, leading to more inclusive environments in turn.

Processes of emergence within cities are < unavoidably complex and as current design approaches are still dependant on reductive methodologies (with an inability to recombine layers of information again in the form of complex systems) the resultant approaches are predictably inadequate. The impossibility of these approaches to successfully address the process of urban change is hinted at by their contradiction to Wolfram's theory of computational irreducibility. However, there are attempts to re-examine planning and design and invent new methodologies that start as a critique of current processes and incorporate emergence over time as integral parts of cities.

AGENT BASED MODELS & SEARCH PROCESSES (URBAN PATTERNS)

Agent based systems or multi-agent systems/ < simulations are also currently being explored in the study of urban simulations. The simplest of these systems tends to be based around a number of individual entities that are allowed to move randomly, until and unless they interact with each other through proximity rules. The basic data each individual entity carries is the action it should take once it has come across another, e.g. stop, follow, multiply, etc. Hence one agent's behaviour is influenced by another at the local level when they interact. The observable result of many of these systems is emergent behaviour in the form of simulated settlement, flocking and group behaviour that resembles a higher intelligence. While such systems have been used successfully to study group behaviour and network efficiencies etc, our primary interest was in the design of urban fabric, rather than the testing of it. We needed to try and implement models as methodological design tools

13. Jingdezhen – Vibrancy and the Informal

[2] There is an excellent resource online that has been invaluable for our studies and conceptualisation of emergent urban tools by the author of the article.

rather than analytical tools, thus requiring agents capable of interaction with each other and the environment, which could also influence the environment and create it at the same time. Towards this end, instead of simulating the movement of people through specified territories, or the flow of traffic to test viability, the decision was to use algorithmic models of urban elements reduced through abstraction to their most basic sets of rules (e.g. genetic nodes in networks, genetic types in blocks, program based requirement based systems). The interpretation and abstraction of these elements from reality required a degree of a priori knowledge of the built environment itself and the development of an ability through studies on the ground to understand the implied qualities, specific to context, site and social practices, held invisibly in these distilled and coded genetic spatial possibilities.

> The use of various adapted algorithmic processes led to different ways of understanding and working with emergent behaviour. Various projects used combinations of randomised search methods applied to urban genotypes (Holland, 1975) based on genetic algorithms, themselves resulting in gradual build up of varied and complex urban models. These combinations of search processes and genetic algorithms, when used with fitness functions, started to allow the simulation of emergent urban systems like block/road patterns (Alexander *et al.*, 1977) and informal dwelling encroachments over time, resulting in simulated patterns (that could be interpreted with adequate socio-spatial local knowledge). Having set up these simulative systems that accurately generated patterns, it was then possible to manipulate them, interrupt the existing trajectories through the insertion of new elements, and change the rules for the pattern itself, resulting in new patterns.

> By understanding the rules of emergent behaviour and pattern formulation over time through simulation of the designed systems, it becomes possible to model complex systems that include great degrees of emergence and variation, but remain influenceable systems. The last, i.e. 'influenceable systems' is the step that allows the simulative model to become a design tool, to test different options and future scenarios (always requiring interpretation based on the specific socio-spatial possibilities of these patterns on the ground), to start considering that it is possible to plan, design and integrate complex urban situations instead of excluding them from the future of our cities.

CASE STUDIES

Some excerpts from our case studies attempting to develop design tools allowing for the incorporation of complexity and variation through the integration of emergence within temporal urban models are illustrated below. <

LENARD WONG: ALGORITHMS FOR CHANGE

This was an attempt at understanding, modelling and then re-incorporating variations of extracted access and infrastructural patterns into a key urban block that, due to its position as the southern anchor to the city's primary commercial and cultural axis, was inevitably being re-developed. The project extracted the pattern data from this mixed urban block (which was due to change from the outside in, as the other blocks in the city centre) and several other informal and formal blocks in order to define a series of generative tools that could test the redesign of the block, including the insertion of new programs and urban spatial possibilities, while still preserving opportunities for the existing informal community to exist within it. At the point when opportunities for equivalent percentages of informal developments within the block were no longer available, the pattern generator was designed to fail as an indicator of this result. It was possible to test several scenarios to the point of failure, including the insertion of large cultural and public programs within the block, which could theoretically co-exist with possibilities for informal patterns upon redevelopment. <

'I will be dealing with the site in terms of its opportunity matrix, against which generative programs can be run. Outcomes will be 'informative patterns' as opposed to 'solutions'. What's more is the fact that contrary to common belief algorithms can produce results for which there is no intention of prediction of their behavior, enabling a generative process of unprecedented invention.' Lenard Wong

> The image shows a series of states that occurred in an early version of the node-based stochastic search process scripted to generate rule based complex or informal street patterns within an urban block. The study of several urban blocks with informal urban fabric allowed for the distillation of rules controlling node types, numbers of intersections, search methods, various static and moving nodes attempting to find the specified allowable relationships. The experiment in its early form (as illustrated) does not yet have a fitness function allowing it to resolve or fail based on the placement of intrusive programs within the block.

14. Rule Based Street Pattern Search Process

JOHN LYNCH: EMERGENT ECOLOGIES

< This project was driven by a concern for the loss of natural ecology and existing farmland that was occurring due to the planned expansion of the city towards the North-West. Natural habitats, green areas and agricultural livelihoods were all in danger of being replaced with generic low to mid density private commercial and government subsidised housing estates. Despite the designation of this primarily greenfield zone surrounding an arm of the river as an ecological/green corridor, there was only a nominal attempt at preserving or encouraging any natural habitat in reality.

< An alternative approach was suggested through the project combining expanded natural ecologies, preserved agricultural areas and pockets of high density building similar to the historic city centre, in a new form of urbanism organised in interrelated vertical programs, allowing for an emergent opportunities within a flexible set of design parameters that would allow multiple results and interpretations while densifying both natural and man made habitats.

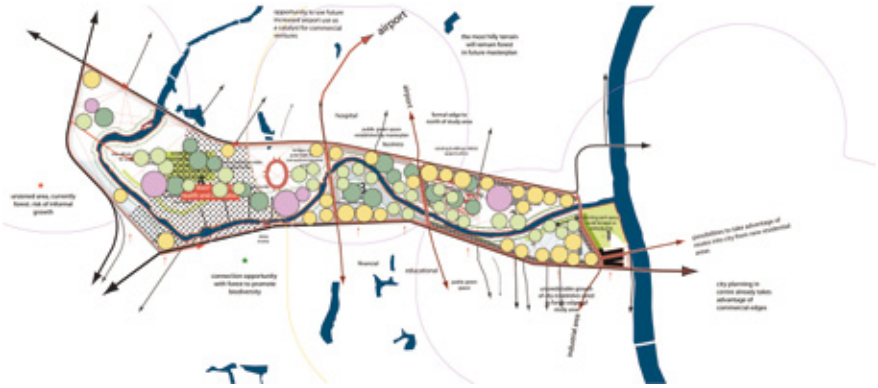
'My studies will focus on an area which has been earmarked for the most development in the next few years. This area is in the north west of the city, and part of it has been described in the master plan as being an ecological area. As there is constant development in the city, through city sanctioned developments and sporadic informal growth, my study will have to take into account the present and proposed future conditions. From this analysis I intend to formulate a strategy in order to steer change and formulate new urban typologies which not only respond to local identity and ecological concerns, but also adapt as the city inevitably transforms around them.

I will argue that it is not only important to react to 'emergent' situations and behaviour whilst designing, but to realise that once a master plan, building or even a bus stop is realised, then it becomes a part of the system and is subject to the rules and behaviour of the system.

This is especially important as an approach to Jingdezhen and many other parts of the developing

world, as the cities are growing at an incredible pace and have not reached the semi-stable state of slow growth that exists in many western cities. If something is to be designed in Jingdezhen, then the architect or urban planner must realise that they are essentially shooting at a moving target, as the many site specific things they may be reacting to could cease to exist by the time they've even finished designing and constructing. This is why it is important to study the emergent values of a city alongside its physical grain. Many of the things that make up the character of a city are the very things that are in flux, such as the hustle and bustle of a market street or the informal meeting areas which form for no immediately obvious reasons. With this in mind it would be naive to just physically recreate the market or the meeting area, but rather to get to the core reasons of why these phenomena have emerged.' John Lynch

The image (Fig. 15-17) demonstrates how multiple interrelated/interdependent layers of programmatic (with associated spatial possibilities) distributions were incorporated into a 3 dimensional circle packing matrix model, that reacted to multiple layers of information and influence both within the site outwith while continuously self organising into possible resultant scenarios.



15. Packing Search Processes on a Charged Site (Several Layers with Interdependent Rules)

16. Physical Site Considerations (selected)

17. External Programs and Influences

ERIC CHEUNG: HETEROGENEOUS INVESTIGATIONS

> The project examined the planned redevelopment of the existing dense informal fabric of the city centre in Jingdezhen. An alternative possibility for this massive restructuring of the city was examined as a critique towards the various degrees of erasure of the existing fabric, planned displacement of the resident population, Cartesian formal homogeneous block typologies proposed and disneyfication of the retained areas. The proposal is based on an understanding and application of identity primarily related to pattern memory. Instead of attempting to preserve the existing fabric as it is, the intention is to address the negative issues, like the lack of fire access and basic infrastructure, while allowing a gradual redevelopment of the area building on existing patterns, through the recognition and incentivisation of emergent processes at a finer urban grain in the heart of the blocks, balanced with the formal and commercial pressure from the main street edges.

'Jingdezhen, situated in the Jiangxi province in China, is a city currently undergoing critical massive transformation with a long history in its porcelain industry. The changes are primarily induced by the political intentions to encourage rapid urban growth and external investment in real estate. There is an active promotion, based on the city's history, of porcelain as the main cultural asset of the city to encourage tourism and foreign exchange. This is part of the economic aspiration to become more competitive, attractive and a differentiated city, from the other cities competing to attract urban development, industry, tourism and investment. The situation exists in a context where the policy for the lease of land to private developers at a national scale was loosened up creating a new market economy. The political move allowing privatisation of land ownership is being embraced by the local government, leading to drastic changes in the city with large scale high rise developments and infrastructure, built to attract more investment replacing large areas of historic urban fabric. At the same time, parts of the city are being converted into a hyper real historical environment to brand Jingdezhen as a porcelain city with a long history. Both trends of developments are leading to the decline of the authentic reality of the city built as layers of history with cultural and social associations.

The urban form of the informal urban situations in contrast to the new organised formal homogeneity of a city without a past provides interesting diversity and variety in the character of the city; but how is it possible to keep the heterogeneity with new developments to sustain the urban growth while addressing the social-cultural needs of the people?'

Eric Cheung

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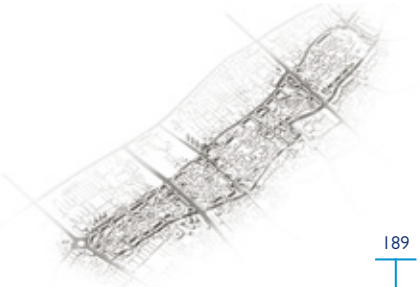
The images (Fig. 18-20) provide three scenarios, the existing, the planned and the alternative possibility. The alternative possibility mixes top down and bottom up approaches, in order to design future possibilities based on enhancing the existing urban patterns and routes, introducing new urban types and possibilities, examining the probability of certain existing and new genotypes locating and adapting themselves in certain places/conditions through stochastic search processes, emulating the self built historic fabric and incentivising the future possibilities of this process. The formal edges of the blocks are driven also controlled by design parameters based on existing density requirements, while being interrelated to the environmental conditions created for the interior of the blocks and the edge conditions created between the formal and the informal. The whole system is based on looped algorithms with fitness functions allowing for controlled and controllable degrees of emergence.

18. Existing Topology of Jingdezhen City Centre

19. Probable Resultant of the Homogeneous Cartesian Approach



20. The Alternative Approach – Illustration of one scenario using Design Tools that include Complexity & Emergence