Generative and Participatory Parametric Frameworks for Multi-Player Design Games

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Introduction

Generative design processes have been the focus of current architectural research and practice largely due to the exploration of the phenomenon of emergence within self-organisation, generative grammars and evolutionary techniques. These techniques have been informing participatory urban design modalities, which are investigated in this paper by critically reviewing theories, practices, and (software) applications that explore multi-player online urban games, not only with respect to their capacity to facilitate online, trans-disciplinary, expert collaboration and user participation, but also to support the implementation of democratic ideals in design practice.

Emergent and generative design processes

Generative design processes based on self-organisation increasingly replace the exclusive, top-down control of the designer. Self-organising swarms, for instance, are employed in generative design processes, which deal with large amounts of data that sometimes feature conflicting attributes and characteristics.[1] These attributes and characteristics are incorporated in behaviours where design components, such as programmatic units, swarm towards targeted spatial configurations. In this context, architectural and urban design become procedural instead of object-oriented, while architectural and urban form emerge in a process of interaction between all parts of the system. Thus, the architect becomes the designer of a process and only indirectly of a result.

Such swarms operate as multi-agent systems and consist of simple agents that interact locally with one another and with their environment, based on simple rules that lead to the emergence of complex, global configurations.[2] Their use in design is of relevance because of their ability to embody both natural (human) and artificial, (design-related) aspects. In the context of urban and architectural design, swarms of agents do not consist of similar or identical agents, as both natural (human) and artificial (software) agents may interact with each other and the environment in a bottom-up, self-organised manner. Such swarms are set up as parametric models incorporating characteristics and behaviours that represent the natural and artificial systems themselves, whereas simulations of behaviours show the operation of such systems in time.

Simulations are of interest in this context, not so much for their ability to represent and confirm assumptions or even improve (optimise) design solutions, but for their generative potential, based on emergence. This implies that the design emerges from a process of self-organisation in which the dynamics of all parts of the system (agents and environment) generate the result. Such generative processes implemented in simulations are extensively discussed inter al. by De Landa[3] in relation to the Deleuzian understanding that matter itself has the capacity to generate form through immanent, material, morphogenetic processes.[4] Thus, design as the production of representations of artefacts (by means of drawing, modelling, and simulation) implies systemic interaction between (human and non-human) system components, while authorship increasingly becomes hybrid, collective and diffuse.

Agents, experts (collaboration) and users (participation)

Generative design strategies based on multi-agent systems are employed in computer games and are suited for online inter- and trans-disciplinary expert collaboration as well as for user participation. They are being increasingly explored as a means for exchanging knowledge among experts and integrating bottom-up user feedback into the design process.[5] In this context, users are defined as human agents who use the online computer-based design system without necessarily understanding the system. In general, users participating concurrently in the design process are either experts in urban design or laymen. However, for the sake of simplification in this paper, laymen are referred to as users since they are not only users of computer-based design systems but also users of the urban space resulting from the participatory design process.

Whereas experts establish the parametric framework (as meta-design)that allows, within certain constraints, the exploration of multiple designs by experts and users, the interaction between artificial agents contained within the framework, and human agents, needs further definition. The question concerns, for instance, how agents are defined. In a humanistic sense, agents (natural or artificial) have the capacity to act upon an environment, and, like natural agents, intelligent (artificial) agents in computer science are conceived as entities that are able to perceive through sensors and act autonomously.[6] Both natural (human) and artificial agents direct their activitytowards achieving goals according to preliminarily defined preferences.

Interactions between human and artificial agents may follow principles as described in Actor-Network Theory (ANT), implying that material-semiotic networks are acting as a whole, whereas the clusters of actors involved in creating meaning are both material and semiotic.[7] ANT, therefore, does not differentiate between human and non-human actors, since differences between them are generated in the network of relations, implying the agency of both humans and non-humans, whereas agency is neither located in human subjects nor in non-human objects, but in the heterogeneous associations between the two. This understanding is extensively discussed in De Landa's new- or neo-materialist cultural theory, which rejects the dualism between nature and culture, matter and mind, natural and artificial, wherein reality is considered to reveal itself in material, self-organised processes.[8]

Interactions based on the collaboration and participation of human and non-human agents in the urban design process follow specialised interaction patterns. Experts such as policy makers, planners and professionals involved in making design frameworks, and users such as property owners, tenants, or visitors and guests, establish a rather inhomogeneous population within which potential conflicts of interest may emerge. Such conflicts may be addressed through techniques based on mathematical models for conflict and cooperation described in game theory.[9] As soon as participants, such as experts and users, engage concurrently in decision-making processes from which multiple alternative designs may emerge, the interactive, multi-agent simulation needs to be extended towards incorporating cooperation and conflict strategies[10] and regulating interactions between multiple players (experts and users) and the design environment.[11]

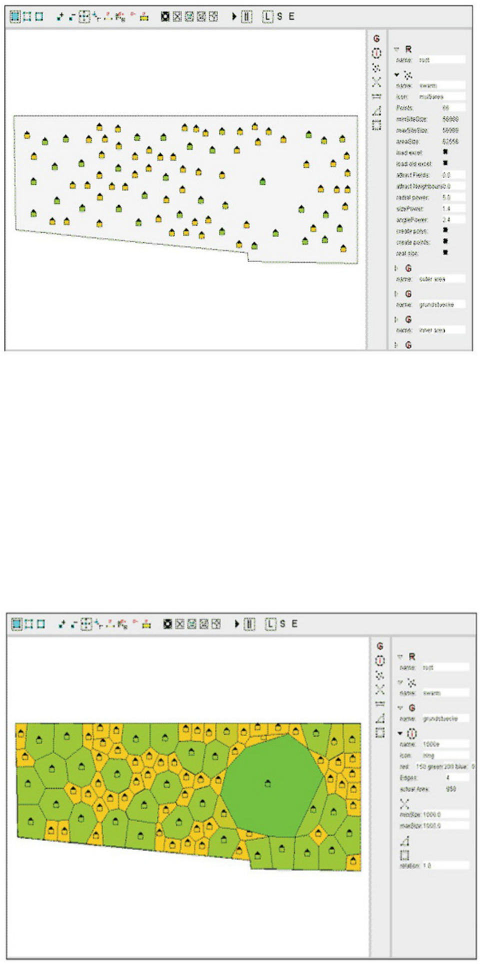

Fig. 1: Screenshots from website showing two instances in neighbourhood design developed within Kaisersrot (2005)

Multi-agent simulation and multi-player online urban gaming

Multi-agent simulation and multi-player online gaming enable collaborative design on the one hand, while on the other, they facilitate participatory design based on the assumption that (expert) agents and (user) players interact with each other in the virtual design environment with the aim of achieving design decisions. Within certain limits and constraints predefined by experts,this design process offers opportunities for spatial reconfiguration according to the needs of users, while potential conflicts between users may be addressed through game-based conflict managementthat employs negotiation strategies such as bargaining, mediation or arbitrationaimed at finding a compromise.[12] However, conflict resolution neither really adds nor detracts from democratic participation because negotiation is implemented by enabling users to choose preferred solutions from a set of possible ones within the given parametric framework, while the amplitude of choice stays within the scientifically sound and valid field of solutions, framed parametrically by experts. This means that users cannot arbitrarily generate solutions, but have instead to contribute to and choose from a set of scientifically valid, possible solutions. Parametric constraints for possible solutions are defined, for example, according to functional, formal, material and structural requirements, identified as such within the architectural, engineering, and building sciences, thus excluding any possibility of generating scientifically invalid solutions. For instance, spatial dimensioning is numerically constrained in relation to min-max occupancy and use requirements; access opportunities are defined in relation to the shortest connection to infrastructure, and so forth.

In this context, games are simulations of design for the purpose of analysis, the exploration of multiple scenarios and the prediction of potential consequences. The question is, therefore, if such online participatory urban design processes simply serve and help implement pre-existing ideals (such as democratic participation in decision-making), or do they also determine and shape political aims, or the specifics of the ideals in question?

Considering, for instance, that political positions representing values such as egalitarianism are easily facilitated by multi-player online design games because these include minorities and disadvantaged groups in decision-making processes, and also promote the freedom to make decisions remotely by means of electronic device(s) in the absence of top-down control, then online gaming may not shape new political ideals, but it does offer a platform for exploring and choosing not only between possible design solutions, but also mechanisms for practising democracy by establishing an interactive interface between experts such as politicians, urban planners, designers and users.[13] And even though the ANT notion of agency, which incorporates both human and non-human aspects, seems – in theory – to contradict the idea of a democracy focused on human agency (via participation), in practice, non-human agency is conditioned to operate exclusively through interaction with human agency, and thus procedurally facilitates human decision-making by compensating where human decision-making might be limited or overextended.

Urban design simulations like Kaisersrot, for instance, generate spatial configurations based on swarm intelligence while taking into account users' preferences, so that urban components, such as housing units, infrastructure and so forth, organise themselves towards configurations that aim to satisfy preliminarily defined requirements with respect to size, distribution and placement within an urban plot, and in relation to neighbours, accessibility, and density constraints.[14] [fig. 1] Users indicate their preferences with respect to placement within urban plots (in relation to parameters such as proximity or distance to public functions, access

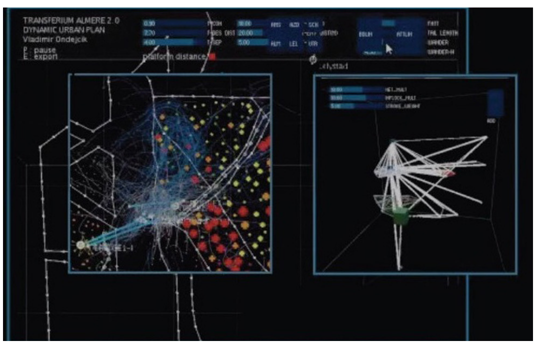

Fig. 2: Urban simulation presenting layout of functional distribution by Hyperbody MSc student Ondejcik (2011)

roads and transportation, etc.), spatial orientation, type (single, double or row-units), size, etc. and the design tool – operating as a parametric framework predefined by experts – generates and optimises neighbourhood configurations as well as negotiating conflicts.

Following a similar set-up, interactive urban design tools developed at Hyperbody in the last decade also employ swarm intelligence. They consist of software agents implemented as functional units that interact locally with one another and with their environment in the following way. Programmatic units pertaining to a neighbourhood are defined as flocking agents striving to achieve a preferred spatial layout. In this context, spatial relations between programmatic units can be described as rules, according to which all units organise themselves. Although the designer might find it difficult to have an overview of all functions and their attributed volume and preferential location, functional units can easily *swarm* towards locally optimal configurations.

Whereas programmatic layout deals with the placement of functions in 3D-space, software prototypes developed within Hyperbody rely on a simple strategy: spatial units establish relationships with other spatial units by determining their distance from each other and automatically adjust their width, length, and height in order to prevent potential misplacements, overlaps, and collisions. [fig. 2] In this context, programmatic units adjust themselves to their surroundings and link with other units, thus creating spatial relations that are defined and simulated by taking a programme of requirements (the number of specific functions, their volume and occupancy numbers, etc.) and translating them into organised spatial layouts. Such layouts are achieved by defining min-max distances between objects, such as units and surroundings, based on rules of attraction and repulsion.

These self-organisation mechanisms are complemented by interactivity, since the layout process takes place within the influence of experts and users, who can directly select and move objects or adjust parameters while the simulation re-adjusts to the new input values. In this way, interacting artificial and natural (experts and users) agents search for preferred programmatic configurations, whereas the users' choice is limited to a range of high and low density, high- and low-rise typologies, and diverse-hybrid or mono-homogeneous programmatic functionality predefined by experts.

Such generative, interactive design tools continuously receive and send data via a database, which contains all the information regarding programmatic units. These are defined by type, function, scale, and position, 24/7 use, etc. Other design-related sub-tools running in parallel might use these values or combinations of values in order to allow experts to investigate structural, formal or environmental implications. These tools are therefore used interactively and in combination with other software, in order to achieve locally optimised designs; and even though diagrammatic, these applications demonstrate an obvious capability to support the functional layout of large and complex architectural and urban environments based on emergent swarm principles.

Similarly, Space Fighter developed by MVRDV/DSD aims at addressing urban design issues at neighbourhood, city, and regional scale.[15] [fig. 3] It consists of components such as (mobile) agents, building blocks (pixels) and programmatic functions represented in different colours, whereas agents may take on the role of users (such as technocrat, ecologist, developer or activist), and seek suitable sites where they could start building additional layers of building blocks. In this case, the amplitude of choice is reduced to the attributes of predefined roles: for instance, the developer may focus on financial gain, whereas the ecologist may choose the sustainable management of resources.

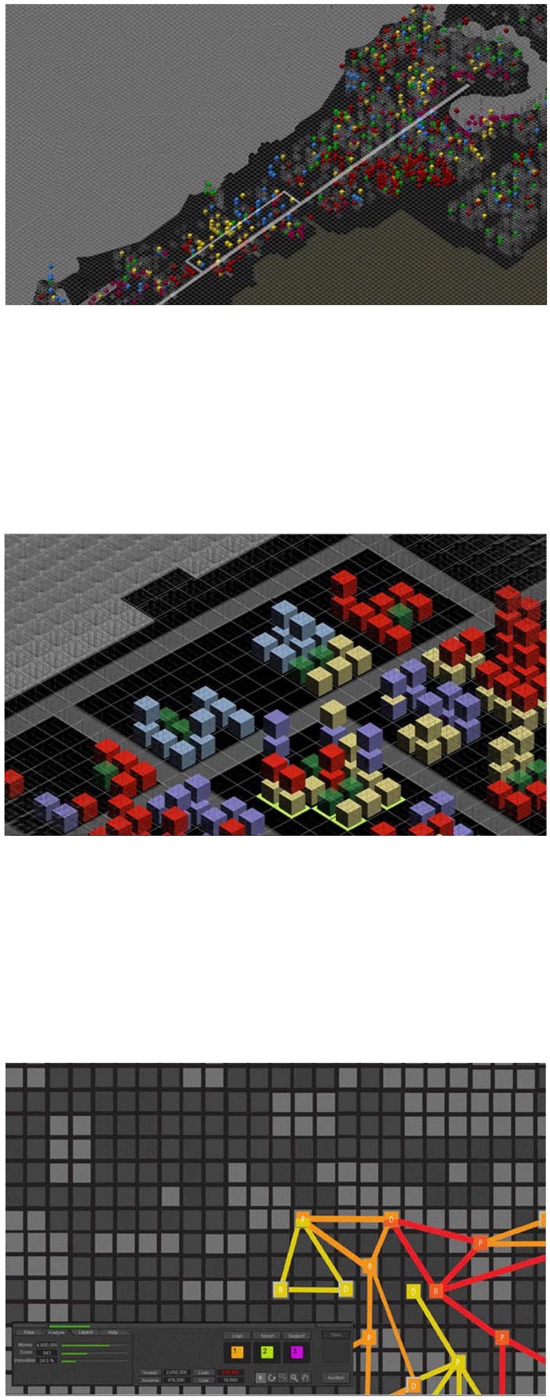

Fig. 3: Urban simulation presenting layout of functional distribution in Space Fighter (2007)

Conflicting positions can be resolved by comparing how close the design solutions are to achieving the set aims.

While the range of choices varies among the reviewed software, neither Space Fighter nor the other software applications reviewed are addressing the important issues of specificity and differentiation in relation to representation and generation, or the manipulation of designs. This is firstly because these prototypes use a rather abstract representation that seems to address expert requirements more than regular (layman) user needs; and, secondly, because these simulations have not been implemented and tested as participatory online games, and therefore have no cooperation and conflict mechanisms. Also, they have only addressed issues of social stratification and inequity in generic terms. Users are not only players of the game but also end-users of the physically built environment after the game has been played and the environment has been built; experts, however, are planners, architects, engineers, managers and manufacturers, all of whom are only involved in the process until the product is delivered to users. For this reason, both require different design and manipulation agencies. This differentiation between users and experts calls for specific rules of interaction between (natural and artificial) agents and the environment, which, at present, has only been addressed sketchily and neither tested nor implemented on a large scale.

Discussion and future perspectives

This review of some of the existing theories, practices, and software applications has yielded the following results. Generative design processes developed from agent-based simulations may involve natural (human) or artificial (non-human) agents, whereas agency is located in the heterogeneous associations between them. Such agent-based simulations enable interaction between natural and artificial agents (experts, users, and design components) participating in multi-player online games. The games support the implementation of equality and democratic principles in decision-making design processes because they include, for instance, minorities and disadvantaged groups, and also facilitate individual freedom to make decisions, even anonymously, through electronic devices.

In this context, relations between players mainly imply collaboration between experts and the participation of users in the design process, whereas conflicts may be addressed through negotiation and conflict management techniques that could be implemented directly in the multi-player online urban games.[16] However, participatory design decision-making features of the environments reviewed here seem rather sketchy and abstract. This means that while users may indicate their preferences, due to representational shortcomings they lack the relevant insight and comprehension in relation to the implications of their decisions. Also, negotiation between global (neighbourhood, infrastructure, etc.) and local (plot, house, etc.) constraints is implemented within a parametric framework predefined by experts, which implies that certain solution fields may be either excluded or only marginally addressed due to cultural or cognitive preferences.

Although in the last decade such generative and participatory design tools have been developed and tested mainly in academic environments; more recently, similar platforms supported by governmental institutions such as Future Melbourne and VirtuoCity Rotterdam are operating online. Future Melbourne,[17] for instance, offers an Internet-based platform that encourages citizens to voice their opinions and make suggestions regarding the future of the city, whereas VirtuoCity Rotterdam presents a visual platform that allows users, logged in as avatars, to navigate fragments of the city represented as a 3D virtual model.[18] However, neither platform is used for collaborative or participatory design decision-making activities.

Therefore, in response to the insight that the aim to create equality is mainly compromised by the actual inequality between experts and users, the immediate goal would seem to be for experts to set up parametric frameworks (meta-designs) which, within certain constraints, enable the exploration of multiple designs, taking into account the users' lack of expertise in computer science and urban design and, therefore, testing and improving the frameworks to address users' needs. Furthermore, advancing generative and participatory design requires that computer-based environments such as theseare not only accessible to users and easily operated by them, but that game rules and strategies established by experts are transparent and comprehensible to users.

Also, given that in software development the distinction between users and software developers has started to blurmore and more as users who are not professional developers are enabled to create or modify software artefacts (descriptions of automated behaviour) and complex data objects without significant knowledge of a programming language, the conflict between users and experts, at least at the software application level, seems to be increasingly addressed. For instance, in the Programming by Example (PbE) approach, the user introduces some examples of the desired results and/or operations that should be performed and the system generates abstractions as required.[19] This could be a model for experts such as urban designers and computer scientists to consider when aiming to improve expert-user relations in the further development of parametric frameworks for generative and participatory urban design.

The question is, however, not only about the interaction between expert and layman, but also about the relationship between democratic and technocratic aspects. For instance, the more recent application of democratic principles to areas outside politics – for example, entertainment, education and urban planning – implies amongst other things that unpopular ideas, even if innovative and valuable to society, may be rendered unsuccessful. In contrast, technocratic principles promote the replacement of politicians and business people with scientists and engineers who have the necessary expertise to promote values such as sustainability rather than financial profitability. From this perspective, urban design games, as discussed in this paper, exclude the possibility of deriving conclusions by means of voting in general terms, and instead apply scientific methods to urban problems. Voting is thus reserved for choosing between solutions with similar degrees of relevance and validity. Hence, the parametric model establishes a technocratic framework, employing scientific rather than populist criteria. This means that even if generative and participatory parametric frameworks for multi-player design games may not replace politics, they may reduce the bureaucratic apparatus supporting government by establishing a direct interface between experts such as politicians, urban planners, designers and users.

In this context, participation in virtual space becomes not only a model for participation in physical space but also the means to affect physical space directly, because decisions in the virtual eventually take effect in the physical. While users may not always be well informed or knowledgeable about the issues at stake, and the scientific approaches employed by human and non-human experts may be fallible, parametric frameworks exploit expert and user involvement as a playground for challenging the production-consumption gap that followed industrialism. They do this by addressing users' potentially conflicting priorities, and different, or even divergent, expert opinions, through the open exchange of data, information, and knowledge via interactive software-hardware networks.

Notes

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Biographies

Henriette Bier graduated from the University of Karlsruhe in Germany and worked with Morphosis (1999-2001) on internationally relevant projects in the US and Europe. She has taught computer-driven architectural design (2002-2003) at universities in Austria, Germany and the Netherlands. Since 2004 she has been a teacher and researcher at TU Delft, where in 2008 she completed her PhD and became assistant professor.

Yeekee Ku is a PhD candidate at TU Delft and also a tutor at the University of Technology, Malaysia. She has practised as an architect in both Europe and Asia.