SIZE IN THE PROCESS OF DESIGN AND REALISATION IN EMERGING ARCHITECTURE - THE DIGITAL CHAIN APPROACH

Abstract

Emerging architecture, based on computational methodologies directly connected to design and realization, places new approaches in front of us and requires an examination of existing terms. One of them is the principle of the Digital Chain, established by CAAD Chair at ETHZ as an uninterruptible digital process with every step as a programmed entity connected by CAAD/CAM technology to universal interfaces.

This paper investigates size in the design and realisation in emerging architecture following the principle of Digital Chain as a digital approach based on coding, manipulatively iterative, through scale and proportion, by variables. Code is connection from design to realization with complexity in its content of parameters (input) and in variations of received product (output) at one side. However, it is simple manipulation of the parameters (i.e. architectural expressions – size, scale and proportion) used and a complex combination of unique scale with different variables and direct correlations to the proportion as utilization of architectural products, such as drawings, models, prototypes or realizations.

This paper considers emergence of size as a mixture of scale unification and proportion output (dimensionality) as components of code decided on the architect as fluid energy of the Digital Chain approach.

Key Words

DIGITAL CHAIN
EMERGING ARCHITECTURAL METHODOLOGIES
DIGITAL DESIGN AND REALISATION PROCESS
CODE
SIZE
SCALE
PROPORTION
CODE IN THE DIGITAL CHAIN APPROACH IN ARCHITECTURE

Digital Chain is an uninterruptible digital process consisting of design (idea, coding, geometry finding) through construction (structure, junction, prototyping) to production (fabrication), with every step as programmed entity connected by CAAD/CAM technology universal interfaces. The term Digital Chain is established by CAAD Chair at ETHZ. Digital Chain is not a continuous one without the role and position of architect as fluid energy and expert that investigates how digital technology is changing, i.e., the entire process of chain, simultaneously adapting to it as well as decision-making about design solution through parameters.

Digital design represents the transformation of traditional design activities by introducing a whole range of constructive engineering technologies, new materials, production and constructive processes that the computer discovers, allows, conditions and supports.

The main characteristic of Digital Chain is a code as a process adjustment from design to realisation. An architect dictates the relationship between parameters and architecture in code – scales, proportion and size. Generally, scale and proportion in art are both concerned with size, as the relationship between one object to another and object as product to the human body (Fig. 1).

![Figure 1](image)

**Fig. 1.** Vladimir Veličković, Elements et documents utilisés 1979. (*The Tate Gallery 1980-82: Illustrated Catalogue of Acquisitions* (London: The Tate Gallery, 1984), cover)

The scale in code is united, meaning it is all-in-one in every sense. Proportion as relative size between parts of the whole refers to elements in an object as product. Size refers not only to design, but also to dimensionality – architectural product.
In the architectural process of design and realisation of the *Digital Chain* principle, the code is the main driver. All the above-mentioned characteristics together with others needed for the idea are parameters. The main components of the architectural product are created by the demands of context, function, form and the user input. Testing the design code through changes of parameters in iterations as well as checks in prototype on the next level make experiments with any request possible. Experiment as the base of *Digital Chain* is also shown on variables of scale and proportion. The size is a result, product or output, which is changeable and depends on inputs. This means that every needed relationship between the objects is the base or a part of the code. All relationships inside the code and the whole *Digital Chain* process are theoretical and physical, but also social. All kind of connections between parameters of scale, proportion and size are inputs of the code, but also affect size as product of *Digital Chain*.

The complexity, as the reason for use, is not always related to the complexity of form, but also to the complexity of complete concept, appearance or construction of the building as well as to the complexity of relationship, which are the process base.

The architectural process is not interactive only in technological sense, but also in social, meaning that the process is not explained only through the idea, internal and external influences, modeling and carrying out the prototype to the final product – building, but also through many external and internal influences, which are inseparable parts of this process.²

*Digital Chain* is a complex continuous tool for troubleshooting (Fig. 2).

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Fig. 2. *Digital Chain* – scheme with links and connectors
UNIFICATION OF SCALE AS PRODUCT OF CODE IN THE DIGITAL CHAIN APPROACH IN ARCHITECTURE

The computer is no longer a passive digital drawing board, but an active design work tool controlled by the code. The code is a united scale or one scale for all sizes, which literally means connecting idea and production. Through unification of scale it is easily possible to change the scale and to produce drawing, prototype or realisation.

According to Lawson, the use of computer is a wise decision, modeler, draftsman and revokes the skill of drawing in architecture as a drawing board, as well as the ratio of all scales and dimensions. It designs theoretically expected, but practically the unexpected and creative. The mental activity of architects before sketching, then drawing on the computer, today is computer knowledge. However, representation of skills of computer programmes knowledge and their use in design - drawing with point, not just for effect, is an important part of this knowledge.

Here the nodes are the decisions and the arcs represent the directed relationships of a superior decision influencing or providing the context for a subsidiary decision. The concept of graph-based dependency is quite understandable on a small scale. But for the designer (without any supporting software) it is difficult to apply on a scale that is appropriate to real-world problem solving. On the other hand, graph dependency is easily implemented as a programme and can be applied to complex real-world tasks.

However, the programming requires very explicit rules from designers, which is the creative, research and impact approach of a large amount of information and scale. Programming design solves the problem, which is the basis of conventional design. The process depends primarily on the way of thinking, which means that the tool is less important, while the logic of problem solving and architect’s intention are more important. The point is in abstract design, finding rules for generating space and form, and in the surprise that the programme has to offer. This research experience is the strongest aspect of digital coding.

The base of represented design is the drawing, which is connected to the realisation and operates in parallel/in correlation with the word. However, once it would be no drawings in the design, the point would be only in the making - realisation. The drawing is also an instrument, a tester a system of symbols, a
transformation between problems and solutions. The drawing is a presentation of imagination and idea, analysis of and confirms this idea. As Carlo Scarpa says he wants to see and that is just why he draws.

Machines and material give a special treatment of scale. Machines dictate the parts of architectural object related to dimensions, which CNC machines could produce. But, they are then elements of some other concept parts. Zooming in scale with material parametars gives detailed proportions and a bigger size. It also allows the use of materials or different treatment of these materials for different parts or use. These two characteristics give digital offer from prototype through to real realisations in metric and detailed sense.

The Evolution Of The Model
Tools - software and hardware - are more powerful, sophisticated and intuitive. Complex digital designs created using software can now be physically realised through advanced fabrication technology, streamlining the design and evaluation process. More people are able to access these tools and participate in a process of design which was previously limited to early-adopters. The ‘evolution of the model’ is not just in the model itself, but also in how it is used and by whom.

As computer systems and communications capacities help facilitate a large-scale production based on digital information, knowledge and culture, there are also important sociological factors. Together these are the most important drivers of the content in which users have a direct immediate impact to the project, and well-designed computer code allows efficient design judgment on quality. Fabrication of the art allows the controlled use of materials for large-scale sculptures, which would otherwise be more difficult to perform. An example is the use of lace in the way the artist Cal Lane has done.

Understanding of the material on the basis of materials science and traditions of the material leads to improvement of traditional materials with new technologies. At this particularly based additive manufacturing, i.e., fabrication and improving of the space design in architectural scales. Contemporary technologies represent both human challenges and approaches in terms of protection and improvement of living conditions and environment of man. Fabrication of brick as well the wood theme as a friend are always current topics, supported by continuous innovation.
In order to improve digital design culture and work effectively with the potential of performance materials, we need to find new models and methods by which we can support feedback between scales. In architecture, production on different scales has always meant engaging with different types of problems, such as planning, urban design, details or specifications. But the logic of the drawing, the system of design geometry remains the same.

Working with performance materials and connecting it with material analysis, simulation, and production of details, we need to find ways in which many different types of data can be linked, regardless of whether they are geometric, numerical or statistical. As a practice, we should develop principles of modeling that enable flexible, dynamic and interactive organisation of heterogeneous data flows. The most important is that these models must be well integrated with the creative practice of architectural design. The architecture is characterised by its breadth of engagement. It is inconsistent with the single aim of design, but always driven by a network of different and often conflicting meanings of design, and architects’ practices should always find the best possible solution for a given context and current moment. So our tools can not be understood as simple ways of optimisation, but should encourage creative thinking about how this new practice of material can fundamentally change the way we think about architecture, the way we live, work and interact as well the way we treat the quality of the space and the environment that we have created.

We are experiencing a fruitful generation of architecture focused on the possible expansion of the material and formal production. Digital methods are essentially moved to the discipline of architecture, and many roads now characterise this designer’s arena. Architects, involved in the digital process, dedicate to the employment of technology potential for information of design process and equipment of evolution of its projects, and their experimentation is extraordinary in scale 1:1. This approach recognises what Michael Speaks called design intelligence:

Making becomes knowledge or intelligence creation. In this way thinking and doing, design and fabrication, and prototype and final design become blurred, interactive, and part of a non-linear means of innovation.12

As it is evident in the works of large-scale, digital environment, which allow architects to take control of the building process. It shows the relationship between the human body and architectural product in every sense (Fig. 3).
Fig. 3. Realtieship Coded product - Human (Belgrade-Zuerich, 2005-2009)
PROPORTION AS PRODUCT OF CODE IN THE DIGITAL CHAIN APPROACH IN ARCHITECTURE

*Digital Chain* as a result of digital technology in architecture, produces partial or complete architectural products based on partial knowledge or without architectural knowledge. Knowledge of the architects ceases to be the main or necessary, and the product becomes self-important - sometimes as a product of the form and identity, rarely as a solution to the functional architecture. Tools become more powerful than ideas, and their mutual relationship becomes one of the key issues of contemporary architecture.

Complexity, as already said, could be made by complex space atmosphere, not only by complex geometry. The process of *Digital Chain* is improving modeling and the realisation of structures and detail, especially connected to not typical and complex forms. The real example of improving the concept, space, form and material, we can see with *Selfridges Birmingham*,13 as explained by the architects who worked on the project:

> The ambition of this scheme was great. Our brief was not only to design a state-of-the-art department store but also to create an architectural landmark for Birmingham, so that the building itself would become a genuine catalyst for urban regeneration. We have reinterpreted the notion of a department store, not just in its form and appearance but also in the social function such a building now plays in our society. Its relationship to the church is significant, representing the religious and commercial lives of the city that have evolved side by side over hundreds of years.14

Insurance *against arbitrariness*15 is done by architects as set of decisions. Relationship between parts are not just based on harmony, but the base is production possibility of machines, and then relationship between the elements of the whole. Proportion as product of the code is complex and could be analysed through dimensionality in sense of picture and in sense of object dependent on material and machine, also very simple for manipulation.

Dimensionality is the direct relationship between scale and proportion refers to size. Coding is change of dimensions as change of plans. At the same time, it is a different product: model, prototype or realisation. Model is simple, with bigger dimensions and detail starts to be prototype and the highest level is realisation. Also sign of proportion is established as relationship design – prototype and architecture, as well as relationship 2D, 3D and machine product. As can be
seen in great-scale works, digital design makes it possible for architects to take control of the process of realisation.

Today, it is also instrument for obtaining and using of code. The code without pictures and words is only text that is meaningless. By simply manipulating coding, however, we obtain different types of necessary drawings, i.e., the interpretation of idea or performance of solutions. The third dimension is obtained easily. The computer facilitates the prediction of architecture by conceptual structures - presentation simultaneously in various mental modalities, in accordance with the architectural thought, material and machine, and not against it. Digital approach to the design and realisation is a streamlined approach, where digital technology as a tool participates in the process and the creation of architecture.

As mentioned above, digital technology in architecture is basically not associated only with design, but also with the production/making. The machines are based on programmes for production, controlled since the design phase. Thinking about the structure is through digital modeling, analysis and fabrication, with constant cooperation with engineers without surprises.

The continuity of the peculiarities of architects, like every other profession, is also a constant learning. However, architects still have a fear of digital tools based on the existence of products of confusing architecture, which is the consequence of insufficient engagement of architects with precisely using these tools in the design. It is obvious that if we look at the aim of using digital tools in the educational system as a playground for small-scale facilities with open functions as pavilion or sculpture, etc., with the use of the system fabrication,
which tools are automatically associated with the design - coding, we come to the conclusion that it is the most important for architects to know the process and simply learn to organise and coordinate it.

The atmosphere of the space, *sensuality compelling logic are the result of design*¹⁶ as well as the achievement of certainty every time again in the new project. All that has been said is the reason why we are doing the architecture, but with the human and technological scale as a measure. Creativity, existence of our materialised emotions more than ourselves, arising from desire for a home, is the purpose of practicing architecture by architects, and the aim which this architecture must reach. Architecture entails the deployment of pleasure, the build up of passion, the discipline that operates by intellectual as well as physical practices.¹⁷

The architect thinks that new techniques themselves solve the problems, and not perceive the necessity of adapting changes of their behaviour and role in the new system of completed - handing over the project in all proportions. For architect to be a real leader of the digital process in architecture, he/she has to monitor in great detail all information received during the process. Projects driven by the realisation have a significant impact on the construction industry, and indirectly in the education and training of architects. Architecture is the only engineering discipline, in which the solution of the problem is located between the orientation toward the problem and orientation to solution. Expertise in this direction is progressing in all fields (Fig. 4).

A specific type of perception of architects, able to look at the idea in 2D without any means of visualisation, *Digital Chain* gives us a personal contribution in the real creation, testing and designing of digital design applications and tools of realisation (Fig. 5).

Digital architecture conditions the change in standard dimensions and measures in architecture, it is now architecture of large-scale and wide usage. Unlike conventional design and realisation, we are talking, in large part, about automated process with the necessary activities and characteristics of architects. The work resulted in topics of networking on the principles of required distinctive characteristics in two directions - in the of necessity and integrity of architects in the continuity of Digital Chain as a tool of emerging architecture.
By everyday digitalisation and technological improvement of the Digital Chain process, design and realisation in architecture is completely accomplished, so we don’t need any manual process. It is leading us to follow the development of digital techniques as well as conditions for design improvement in future:

At the foundation of computational design is the relationship between tools and skills. We have to match our tools to the concepts around which designers want to build their skills. Our expectation is that geometric skills, compositional skills and algorithmic skills will be the key to future design.\(^{18}\)

The Digital Chain process introduces the digital design – coding and the use of CNC machines in production of architecture in relation to the construction of complex structures and form elements, and not typical aesthetic characteristics (ornaments) with machine parameters input connected with all others coding parameters used through the whole chain. In this way, existing elements are receiving new data through the change of dimensionality and size (Fig. 6).
Digital Chain represents design process as the code, i.e., a unique formation of information from general to individual in the form of data concept analyses and synthesis:

Technology is established according to the logic of its own formalistic development, which parallels and shapes our development in history, culture and nature. It is constructed in such a way as to achieve an effect for practical purposes. 19

CONCLUSION

Related to term Digital Chain as an uninterruptible digital process with every step as programmed entity connected by CAAD/CAM technology universal interfaces, the code is the connection from design to realisation with complexity in its content of parameters (input) and in variations of received product (output). It is simple to later manipulate used parameters (i.e. architectural expressions – size, scale proportion). Code provides possible combination for unification of scale with variables of dimensionality and other parameters. It is in direct correlation to the proportion and use of architectural products, such as drawings, models and realisations. Compared to the change of magnification in a view zooming in and out by camera, it gives the same possibility of changing scales and proportion in architectural design and realisation by the Digital Chain approach, and adding dimensionality at the same time with different character of output.
The code is integrated in all parameters inside itself. It gives one measurement and all relationships as relative and absolute at the same time. It can be changed as needed. Output as space is always flexible as well as today’s efficiency of space needs. Some of them are the relationship of space and microspace dimensions as the size of architecture in sense of in large of parts scales.

The topic is based on overlapping stable approach in the process of design and realisation in architecture with advanced digital tools based on the required function, concept and context, not only on the architecture in which the form or structural system dictate the spatial appearance, what was originally the case with the uncontrolled introduction of digital tools in architecture. Approach in between and beginning of design digitising is just a continuation of the standard design, where drawing on computer replaced the one by hand. The next step in the development of digitisation of architecture was the use of machines in the performance of irregular shapes. Designing these kind of forms and determination of the final solution are facilitated at one point by computer, and it also determined the transfer of information. Process improvement primarily relates to the inclusion of the realisation to the phase of design, connecting the design and practice, solving the complexity and control by architects, relying in the form of amendments to the education in the direction of digital design and realisation.

The new role of the architect is setting the strategy of future architecture. The architect creates the process indirectly returning to the realisation - knowing the parameters of machines and materials needed for encoding idea, and directly in terms of product control. It suggests the greater position of architect in the development of application programmes, which are necessary for the development and realisation of idea.

Layered complexity of the emerging architecture crossed with new design activity, in relation to Ludwig Wittgenstein, as the most complex activity that people perform, resulting in problem-solving in contemporary architecture through human activity, with the inherent characteristics of emotion and communication as control in digital architecture.

The size of digital influence in architecture is also the topic of size in art and architecture and it is open for new research opportunities. Open parameter for experimentation is the size of the architectural space comparative to the size of the idea and known topic – unknown result as psychological or social moment in emerging architecture.
NOTES

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4. Ibid, 72.


10. Ibid, 105–118.

11. Ibid, 121.


14. Ibid.


17. Ibid, 34.


Aish, Robert. ‘From intuition to precision.’ *AA Files*, No.52 (2005), 62-63.


VELIČINA U PROCESU PROJEKTOVANJA I REALIZACIJE U ARHITEKTURI U NASTAJANJU - DIGITAL CHAIN PRISTUP
Sladana Marković

Arhitektura u nastajanju, zasnovana na računarskim metodologijama direktno povezanim sa projekovanjem i realizacijom, postavlja nove pristupe pred nas i zahteva ispitivanje postojećih pojmova. Jedan od njih je princip digitalnog lanca (Digital Chain), koji je uspostavila katedra CAAD u ETHZ-u kao neprekidni digitalni proces sa svakim korakom u vidu programiranog entiteta povezanog CAAD/CAM tehnologijom na univerzalne interfejsje. Ovaj rad istražuje veličinu u projektovanju i realizaciji u arhitekturi u nastajanju prema Digital Chain principu, kao digitalnom pristupu zasnovanom na kodiranju - manipulativno iterativnom, sagledanog kroz razmeru i proporciju, pomoću varijabli. Kod je veza od dizajna do realizacije sa složenošću u svom sadržaju parametara (input) i u varijacijama primijenjenog proizvoda (output) na jednoj strani. Međutim, to je jednostavna manipulacija korišćenim parametrima (tj. arhitektonskim izrazima – veličina, razmera i proporcija) i složena kombinacija jedinstvene razmere sa različitim varijablama i direktnim korelacijama sa proporcijama kao što su korišćenje arhitektonskih proizvoda, kao što su crteži, modeli, prototipovi, ili realizacije. Ovaj rad razmatra pojavu veličine kao mešavine objedinjavanja razmera i proporcionalnog izlaza (dimenzionalnosti) kao komponenti koda koje arhitektu percipira kao fluidnu energiju pristupa digitalnom lancu.

KLJUČNE REČI: DIGITAL CHAIN, NOVE ARHITEKTONSKE METODOLOGIJE, DIGITALNI DIZAJN I PROCES REALIZACIJE, KOD, VELIČINA, RAZMER, PROPORCIJA