The necessity of the application of genetic algorithms in architecture

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Abstract: The challenge today is building the world engineering optimization. Given the extent of today's projects, data quantity and complexity of many construction projects, beyond d the designer's ability to understand and forecast the project is complete. Genetic algorithms including computational techniques based on evolutionary law that has recently entered the field of architecture, Issues that are complex in function and form, to be used. The purpose of this study is a function of genetic algorithm in the architecture and whether the genetic algorithm is used to create innovative forms or is merely a tool to optimize the Materials and Methods "descriptive analysis" is done.
The results show that the use of genetic algorithms in the architecture can be seen as a combination of necessity and desire It as a tool that can be applied to meet the specific Necessity of architect And not merely an experimental design, based on genetic algorithms is to assume, Also as a tool to solve mechanical problems and structural optimization - making create form And powerful tool for layout design, space planning, is used. In recent years, genetic algorithms successfully been used in some construction projects.
Keywords: Genetic algorithms, Evolutionary algorithms, Optimization, Architecture, necessity.

1. INTRODUCTION

Genetic algorithms, including algorithms that search is a search space to find an optimal solution to search, It forms as a tool to optimize create and powerful tool for designing space layout plan will be used. Optimization is the "optimal search of answers or responses in order to increase efficiency." Wherever the optimization problem considered is a naturally select the appropriate search method, the main concern is the optimization process. With the advent of faster computers, new techniques were developed to optimize. Be tantamount to a variety of techniques such as evolutionary algorithms, ant colonies, neural networks, and genetic algorithms and inspired by nature emerged. The main idea of evolutionary algorithms was introduced by I.Rechenberg as evolutionary strategies. (Ingo, 1973: 34-70) Evolutionary algorithms that solve the problems using Method of trial and error and repeated calculations and repeated calculations starting from an initial guess is done, Highly successful act. The idea of I.Rechenberg was developed by other researchers. But genetic algorithms by John Holland (Holland, 1992: 66-72) and was invented to help students and colleagues That ultimately led to the book adapted to natural and artificial systems, in 1975 Patrol. (Holland, 1975: 12-18)

Genetic algorithms, including evolutionary methods that can be used for optimization. This algorithm is based on natural genetic mechanism works, the generation of a population so that only species that have the best properties and those who do not have this property and gradually disappear over time. Genetic algorithms have been engineered in many areas and have become accepted as fact. But it seems that still have not found

its place in architecture. Architectural projects are larger and more complex every day, and consequently the quantity of data more and the appropriate option to select from among numerous options may be more difficult. In such circumstances Necessity to be more intuitive modeling tools ¬ can be optimized. The quantity and complexity of projects has increased to such an extent virtually impossible to fully understand the conditions and the correct decision to withdraw from the architect. Ninety of the decade, there has been a transformation in the style of the leading architects And the use of evolutionary methods like genetic algorithms, to overcome the increasing complexity of contemporary architectural projects. Despite the enormous size of dinosaurs and more powerful example of the survival game they lost during the normal process, Much weaker than the creatures they continued their life. Apparently, nature does not select the best based on physique! The more correct to say that nature will choose the most appropriate nor the best.

Consider a group of rabbits. Suppose that the number of rabbits minds are better than others. These numbers have less chance to survive. Because chances are eaten by foxes, more. Nevertheless the minds of some of these rabbits will survive, because there - have a chance. However, more live rabbits, rabbits are alert of the average previous population and this number will start to reproduce. Baby rabbits, faster and smarter than previous generations are rabbits, the faster and smarter rabbits, foxes have escaped from the hands. After the rabbits most parents faster and more intelligent forms, and their genes are passed to the son of rabbits and this procedure will be repeated in subsequent generations. The performance of genetic algorithms are based on it. A genetic algorithm with a population of N sets of possible solutions to a problem, as the search begins. Population, a set of chromosomes or candidates within the solution space is defined. The first step should be the first generation. The first generation of chromosomes randomly from among the range of possible solutions to problems are caused. After the chromosomes of the first generation to reach the target population, each chromosome is evaluated as a solution and subsequently allocated to it a fitness. The chromosomes are arranged according to ascending levels of fitness. Genetic algorithm uses the policy of meritocracy. Means that only a percentage of the corresponding chromosomes with best fitness values have been, are selected for reproduction. The percentage for the algorithm, will be defined. Half of the chromosomes can be present generation to the next generation, was selected. If convicted on the remaining chromosomes are eliminated. This process of genetic algorithm is one of the main operators, selection is called. By applying this method until the best are the best solution, we preserve and transmit to future generations. The next step, the second generation should be established. Be assessed for the second generation, it should be the first generation population of chromosomes. Other news from this time will not be initialized, but empty half of the second-generation capacity will be completed during the birth. Fertility can be done in different ways the most important, is the intersection operator. Near the intersection, a small contribution to the mutation operator there. Create a new generation at each stage so that the objective function will be improved compared to previous generation Or at least remain constant, but in any case had not regress. Generation continues to be one of the criteria to decide to stop it. These criteria can be established number of generations, stable optimal solution in a certain number of generations, the difference over a certain amount in successive generations.... And it is. Due to the repetitive cycle of the genetic algorithm, the use of computers as always seems to be inevitable. Developing ways to use computers and advanced genetic algorithm was smoother. In 1992, someone named John Koza Genetic algorithms in the form of computer programs to perform a series of processes to be used (Koza, 1992: 65-90). In recent years, major changes in the genetic algorithm has been And further work in order to use these algorithms in different environments And genetic operators are suitable for specific applications.

Nowadays genetic algorithms to solve a wide range of numerical problems, such as optimization of traffic signal control, subsonic wing design, hydraulic actuator design, urban planning, design, antennas, control systems, groundwater monitoring, system design water supply, extensive pile foundations were designed, leaving a trace in the structural design of concert halls, and ... Are used. Fortunately, the architecture is also benefiting from new techniques such as genetic algorithms to optimize the response by the move. In recent

years, genetic algorithms to successfully optimize the different cases are handled (Xu, 2009: 9-100- Calds, Norford, 2001: 5-418- Calds, 1992: 1-15).

2. Methodology

Emergence of Genetic Algorithms in Architecture

Change in the style of the leading architects of the 90s has been observed and Biological evolution of the technologies used to overcome the increasing complexity is to visualize Architecture that exists today. While traditional design methods can not address the complexity of today's projects are in progress. In addition, data quantity and complexity of many construction projects beyond the designer's ability to understand and forecast the project is complete. In such circumstances, it seems that architects should make use of new techniques for dealing with current conditions. Evolutionary algorithms are genetic algorithms, including that in recent decades in many engineering fields have been entered and have been accepted as fact.

These algorithms have also recently entered the field of architecture Issues that are complex in function and form, to be used. In the absence of a growing tendency to use genetic algorithms in architecture there is still check on the functioning principles of Genetic Algorithms and its use in architecture is not performed. Some of the questions about the use of genetic algorithms in the architecture are as follows in this study, which is trying to exact any of these questions be addressed:

- What is the use of Genetic Algorithms in Architecture? The genetic algorithm is simply a desire or Necessity comes from?
- The genetic algorithm is used on specific issues or just for creating complex forms and is innovative?
- The genetic algorithm, the traditional design process and the architect's role has changed?
- And finally the selection of the output, a measure of what is done?
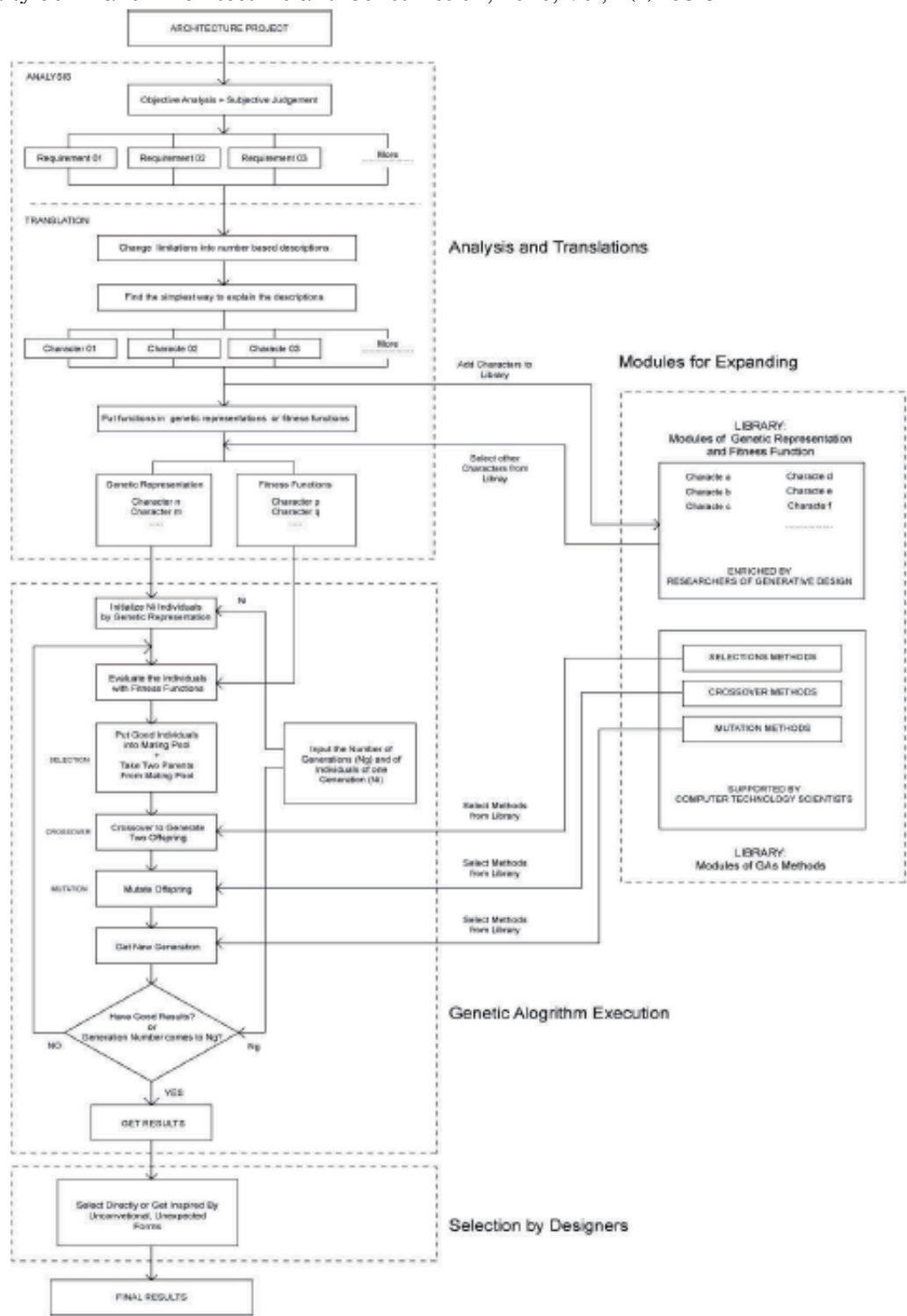
Table 1: Cycle of Genetic Algorithms in Architecture (Source: authors)

Genetic algorithms differ in architecture and other areas

Can be stated that the application of genetic algorithms in architecture, is a fundamental difference with other areas. Unlike other areas in which the target is well defined, many issues have not been clearly defined in the field of architecture, many issues have not been clearly defined in the field of architecture. Liddament in his article titled "algorithmic paradigms in the study design" shows such as genetic algorithms computational tools, although powerful in solving many problems in scientific work, but they are not suitable for real. Even if the designer does not regulate the design process, there is no guarantee for a successful design. The reason is that an architectural project, a combination of several different functions such as space, structure, lighting, sound and heat. These parameters are interacting with each other in the design process. As a result, another fundamental difference between architecture and other fields is that architecture is not merely a rule-based knowledge. While the architect is

primarily engaged in the performance of buildings with cultural issues, social and aesthetic is also facing.

Applications of Genetic Algorithms in Architecture

One of the fundamental questions about the use of Genetic Algorithms in Architecture Today, This is taking advantage of these algorithms is the Necessity comes, or a desire? First, you should review the Necessity and desire to be paid in architecture.

The **Necessity**

Human growing necessitys and lifestyle of today, Requires more sophisticated tools for the design and the demand for innovative and newer forms of this ads complexity. The resulting complexity and quantity of relevant data, the architect of the major issues facing todays and The problem with traditional design methods, is not soluble.

In addition to the existing provisions, beyond the capabilities of designers to understand the problem and their solution is predicted. In the absence of the other areas, computational tools based on biological principles - Evolutionary Biology are accepted, still in the architectural field, evolutionary processes have been widely used. The recent dramatic developments in architectural style has caused architects such techniques - which are tested in the face of complex issues. Despite the difficulties in coding, there are many architectural issues, Genetic algorithms as a method for solving optimization problems, which offers thousands of repetitions

performed in one second, And finds a set of solutions, the designer's mind opens to the world of the unknown and unimaginable complexity. In terms of Necessitys, architectural project of the genetic algorithm, it is defined as a tool for optimization problems, such as functions, structural, mechanical, thermal and lighting are utilized (Calds, Norford, 2001: 5-418). In this case, genetic algorithms and real-world architecture is designed to serve. In recent applications, the use of genetic algorithms is the notion of urgency and as a tool for optimization. The reason that you Necessity is called a genetic algorithm, so Amrst. (Calds, 1992: 6-11). After this, the application of genetic algorithms as the "Necessity" to learn - be.
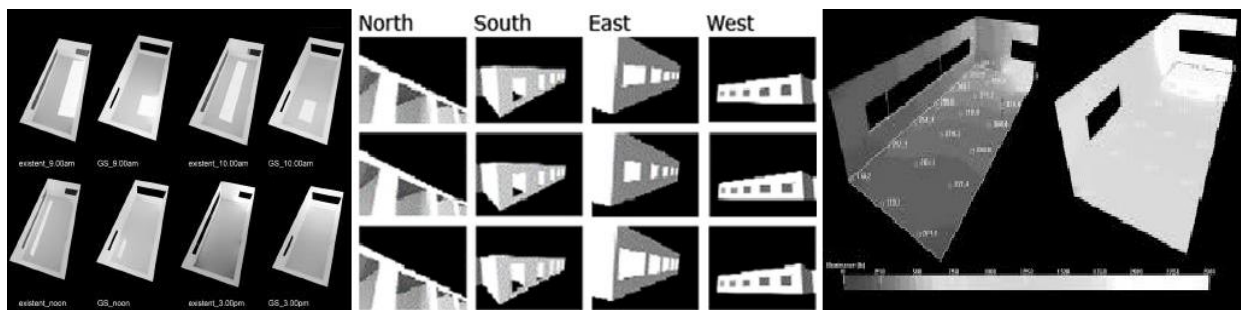

Figure 1: Utilization of genetic algorithms for optimal design of the windows - to reduce energy consumption

(Necessity) (Calds, 1992: 1-1)

The trend

On the other hand, witnessed the pervasive use of genetic algorithms as a tool we are creating the form (Xu, 2009: 9-100). In this sense, Architects of genetic algorithms to create innovative forms and describe the processes related to the use of structures Complexity are often very large. Number of architects who are using this technique, is growing rapidly and with this process, projects are more complex and sophisticated. The study also projects output, one can conclude that the apparent complexity, the basic premise is this group of architects. The fact that these forms are not often serve the function and structural requirements, the discussion of "desire" adds. Here are several questions:

- Why the buildings are have become more complex, while serving the Necessitys of this complex is structural and functional building.
- The architects believe that these initiatives are only the complexity of the bus?
- Do they believe that the apparent complexity of the building, can reflect the complexity of the environment and everyday life is the building?

- Why the apparent complexity of the agenda are the primary?

The fact that this group of architects, genetic algorithms are used to create form, structure and function without being in space, is placed alongside the fact that many of these projects, not the architecture, But also to generate abstract forms that are difficult to reconcile it with the architecture. As a result, in this case, Can be said, this type of service that uses genetic algorithms to create visual forms and the world is not reality. Hence, this type of genetic algorithm utilizes a "trend" is called.
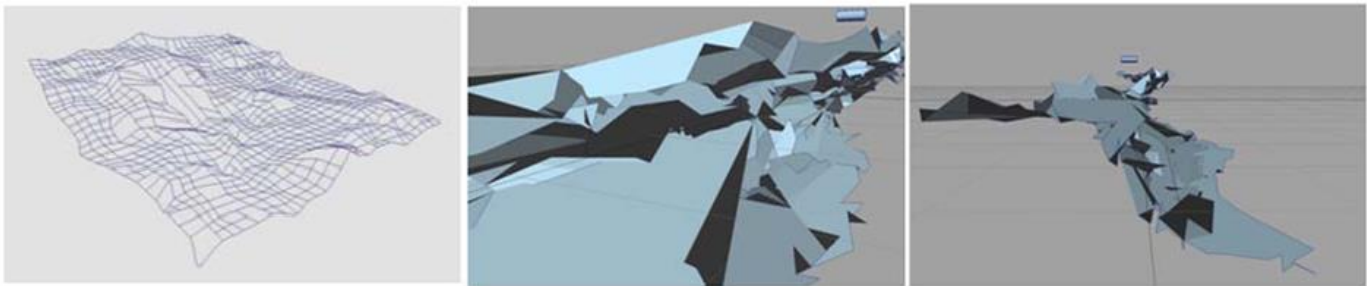

Figure 2: Using genetic algorithms to create innovative forms (trend) (Calds, 1992: 1-15).

Many architects do not really care about the appearance and some do not understand its meaning properly. Does not appear to detail, but knowledge is the totality of the design process is composed of many details, You can not put this part of the pen and will focus only on appearance. Even if so many architects and construction requirements with the production of functional form, they are still wrong in this. This error comes from an open architecture with biology. Although there are similarities between these two. For example, both materially and Sakhtarnd both morphology and structure of pay.

However, these similarities led to a sense of biology in the building, with the same basic principles governing nature is not. This mistake, which is equivalent to the organic evolution of cultural evolution with Darwin's theory of evolution similar to equivalent the theory of evolution is Lamarkyn (Darwin, 1999: 20-75). Because form in architecture is a cultural product that many abstract meanings as those mentioned above, includes, can not be defined in terms of Darwinian evolution. What position should be clearly understood that architects, architecture can be assumed as part of nature and in what circumstances and where comparison is possible and can be likened to nature for inspiration? There is no doubt that the conceptual world of abstract

forms, may be implemented in the future come true and the concept appears to open up new words. However, the main challenge, taking advantage of genetic algorithms in the real world and the other is optimized.

Genetic Algorithms in Architecture, a combination of Necessity and trend

Undoubtedly, there are many problems for the use of genetic algorithms in the architecture. However, genetic algorithm has the potential to play that role more effectively in the future architecture. On the other hand, the issue of architecture has a "reason" and an "agent" is essential. "Because" the growing quantity of information and increasing complexity of construction projects today. "Agent" of the building, including space operations, services, aesthetics, construction, energy and lighting. All these functions interact with each other and are interconnected and can not be considered separately. On the other hand, the capabilities of genetic algorithms is proposed. Genetic algorithm approach to dealing with complex issues and finding solutions Bhyn °design is a space defined by the input due to multiple factors, it is bound. If architects want to design an algorithm to use in their issues, Algorithms can produce one of the tools may have to use "reason" with regard to the factors are answered.

Using genetic algorithms to focal

Not for use in genetic algorithms, architectures, in some cases should be done. Current use of genetic algorithms is local, meaning that genetic algorithms for optimization of production or form a structure function is used. The topical issue, is that the performance of genetic algorithms can be changed during the design process and in the end, the best "local" is lost. For example, if a designer uses a genetic algorithm to generate the form, Design in the next step, he Necessitys to local or general, the resulting change to fit the desired form is achieved (Calds, 1992: 1-15).

In such a case to find the optimal form in order to reduce costs and make maximum brightness during the day there. If the designer in an effort to assess and calculate the thermal performance with traditional methods, this risk has been calculated in the step of local optimization is lost. Why else should be evaluated in the next step in performance and new functions are introduced. A solution to this problem, coordination between productions tools, optimization tools are a combination of both genetic algorithms to the user: the Necessity and trend. Through the calculation means that form most often used functions will be created. This process

can be as prone to attempt to achieve the design goal, which is a fit between form and meaning, must be considered. However, not very favorable results may be obtained from this process. Architects must sacrifice some aspects of generalized or limited to some design issues. This may be a problem in translation is unclear where the problem is well defined conditions. This Drvnyat and unconsciously for example architects and related design intent is undoubtedly such a translation would be very difficult. Many writers have pointed to the difficult nature of complex coding issues. On the other hand, according to recent issues that transcend the limitations of design capabilities for understanding and forecasting solution is complete, it seems inevitable that such a translation. Another aspect that architects should consider using this method, many of the issues that are created during the design process and will be updated. The result should be interaction between the designer and computational tools to enable the designer to add the variables, they can reduce or alter the fitness function.
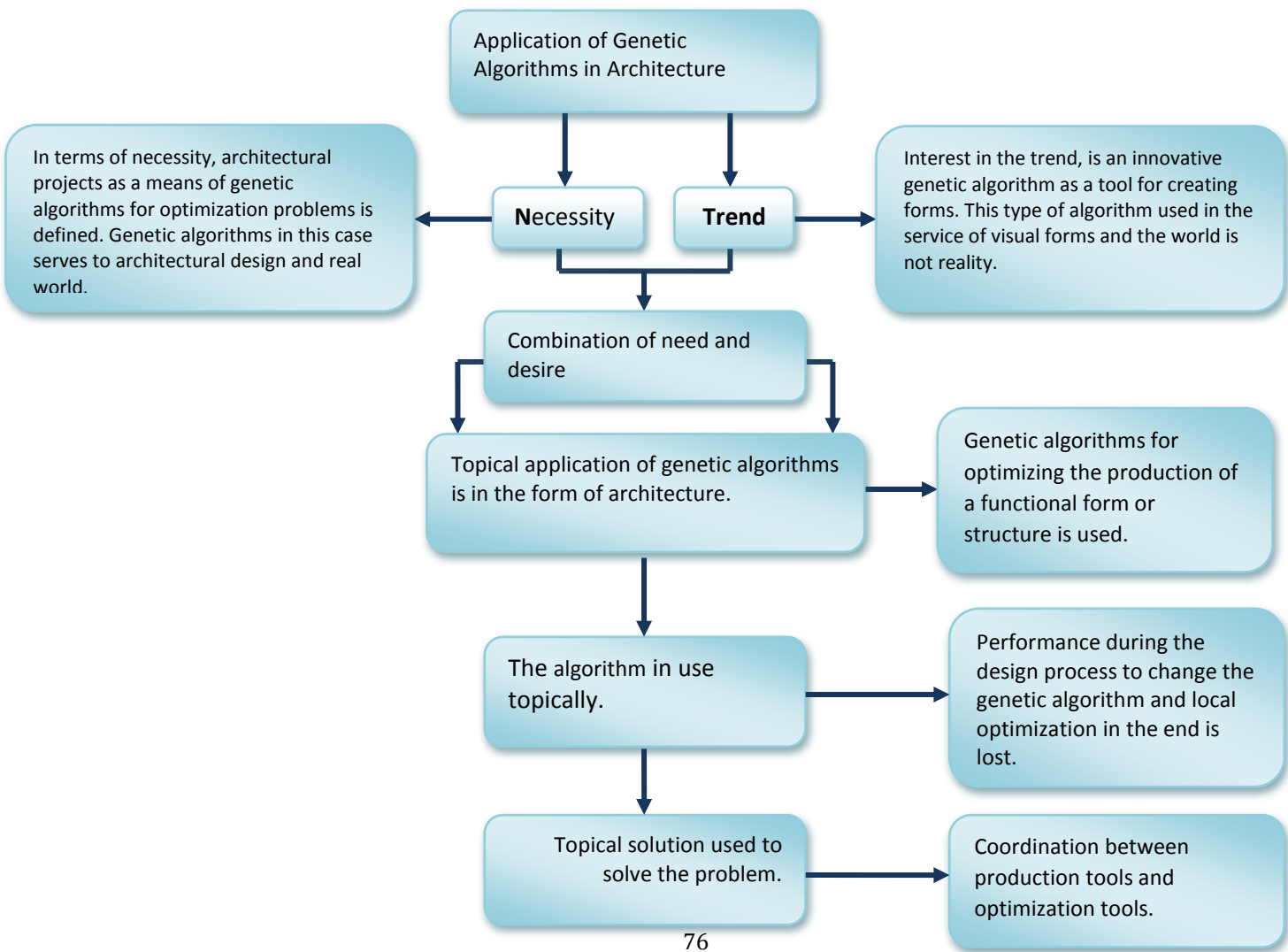
Figure 2: Applications of Genetic Algorithms in Architecture (Source: authors)

Design process and the role of the designer

Changes in the design process, one of the main reasons is the use of genetic algorithms. In cases where the genetic algorithm as optimization tools are used, these changes are very important. At first glance it may seem that these methods are designed to remove the designer of the cycle, but not really. Designer or engineer is actually the only one who decides what should be optimized and the only one that will determine the variables and functions. Optimization tools in the hands of the designer is only as a means by it, reduced cycle time and design calculations. In other words, the reasons for the genetic algorithm is used as a tool to create forms, more importantly, because of its systematic nature of the genetic algorithm, is used in the conceptual phase. Evolutionary simulations replace traditional processes are designed and it is felt that the designer has little role in the second degree is important.

Because much of the design of genetic algorithms to create new forms as soon as they are not designed, has the same problem. Equally the idea of using computers to create new buildings is attractive, it is clear that mere use of digital technology without the support function, structure and topology, will never lead to an appropriate architecture. The designer's most important role in this type of application of genetic algorithms, fitness and aesthetic judgment on the plan.

Select the final answer

Select the final output, is another argument that there is a genetic algorithm. In discussing the Necessity, the result is completely defined and selected, based on the optimum solution. For example, the project Caldas and Norford, aimed to determine the optimal size of window functions with regard to lighting, heating and cooling and the final solution was chosen based on low energy consumption. But the desire to talk, is not clearly defined objectives and selection criteria, is aesthetics. However, here are a few questions:

• Why do designers have such a strict process, reasonable and lawful use, while ultimately selected based on aesthetic criteria is the concept?

• Why are they from the beginning, do not design something like the final output?

・Whether this is because some of the architects of the genetic algorithm as merely a tool focreating distance limitations   in   their   use?

・Do they believe that the use of genetic algorithms in the design process, their work gives theoretical meaning?

Using genetic algorithms in the design space and room layout plan:

Design and arrangement of space, space planning, and architectural design is a key step in the process. Given the capabilities of genetic algorithms in other fields and also used successfully in the field of architecture, you could use genetic algorithms to optimize the search space, significant progress is achieved in the architectural design process. Such action can only be effective on manufacturing costs, but can also reduce the energy consumption. Using genetic algorithms in the design space should be the goal of optimizing and effective parameters identified in the objective function and in the next step is to examine the possibility of encoding parameters. Any better and closer to the reality of these parameters are expressed in the form of chromosomes, the results would be better. Several criteria are involved in designing the layout of a plan. Some of these criteria are quantifiable measurement tools, but others had little Criteria are not quantifiable and hence measurable. The architecture is the same issue with other disciplines. Architectural knowledge is based solely on the law. While at first involve the performance of the architect's buildings, cultural issues, social and aesthetic is also facing. Next, criteria and variables involved in the process of architectural design are introduced:

- Enjoying the sun: The criteria for placement in the room right place and at the proper angle to sun deals. The aim of this work, more use of daylight in the room is the most space possible. These criteria can be entered as a vector measure.

- Landscape: This benchmark position in space rather than the scenery looks good and proper perspective. This measure is aimed at creating the best prospect of scenery. These criteria can also be imported into a vector calculations.

- Access: This measure of distance between the Main Street entrance to the building and pays the minimum distance to the target building. The standard unit of measurement, meters.

- Related functions: Some functions are more related to each other. The aim of operating in this regard, the relationship is some room together and they are one of these rooms should be away from the rest.

- Minimum distance: Purpose, a minimum distance between the rooms to optimize space is Syrklasyvn.The unit of measure, meter.

- Efficiency: This criterion can be obtained from the comparison with the level of Syrklasyvn level. The purpose of this benchmark, using the most space to create room and space for Syrklasyvn is minimal. This criterion is expressed in terms of percentage.

- Space efficiency: This benchmark can be used compared with those obtained Hrfza volume. The purpose of applying this criterion, having more usable space and dead space is minimal. The operating factors such as sunlight and ventilation can be effective. The unit of measure, the percentage is.

- Size: Size of each room, including length, width and height can be based on standard or user type (hotel, school, home, etc.) vary. The unit of measure is meters.

- Geometric composition: Rooms can be placed within a larger geometric forms (circle, square, rectangle, etc.) and are based on aesthetic standards as specified below.

- Golden Ratio: Spaces must be rectangular in design from the golden ratio (1.6180339887) is used.

- The overall three-dimensional form: The overall shape of the building can be linear, central courtyard, U-shaped, L shaped or organic shapes or forms of religious concepts.

- Sustainability criteria: Spaces should be distributed based on sustainability criteria, including minimum levels in the surrounding walls, energy consumption, sun levels, levels of aggregate consumption, is the amount of room light.

- Other criteria: Including economic criteria, structural, religious concepts, techniques and…

The results of the application of genetic algorithms the three-dimensional design space with a measure of taking maximum advantage of daylight to reduce energy consumption is presented. (Lobos, Donoth, 2001: 120-187). Starting point of the design process, using a schematic plan of taking a set of rules, constraints and the relationship between the spaces. Results, the design space for a building has two floors. Sketch plan on both floors, consists of a square, in order to define each room has been divided into four equal parts. Each of

these rooms during the design process to change the length or width have been The height of the rooms on the first floor was limited to a specified amount and fixed. Second floor, there was no limit to the Braynkh addition, the roof angle to the horizontal level of functionality has been changed. Changing this angle range is from zero to 45 degrees. In the following figure, the best and worst results based on criteria enjoying daylight to reduce energy consumption is depicted.
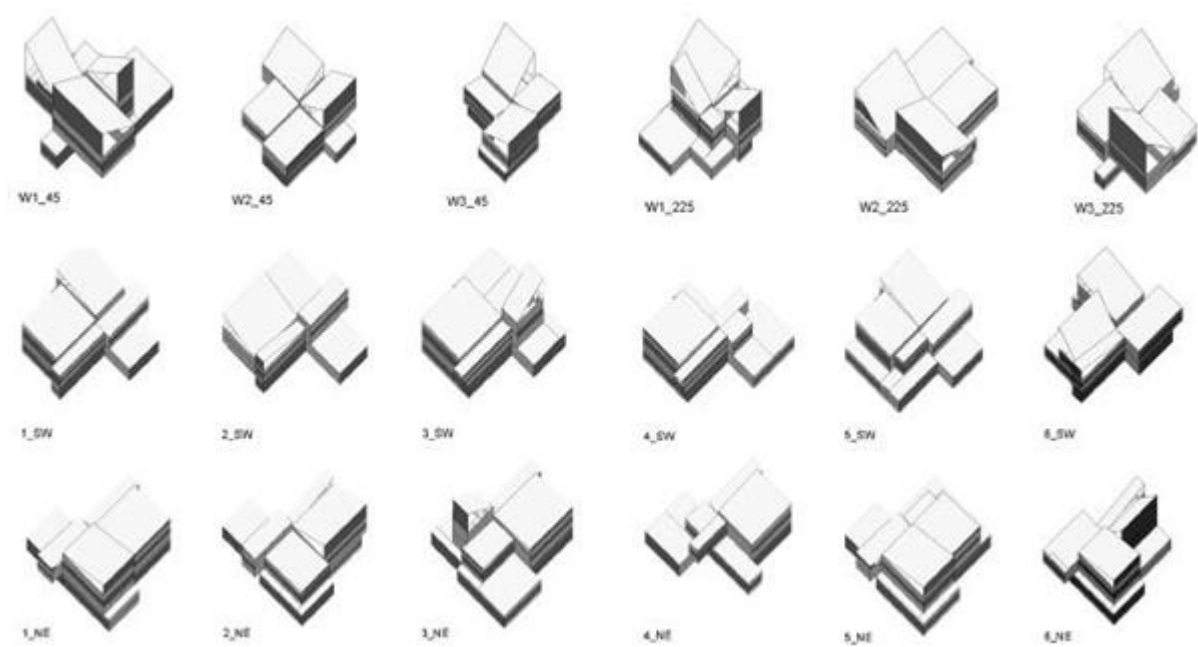

Figure 3: Floor plan sketch

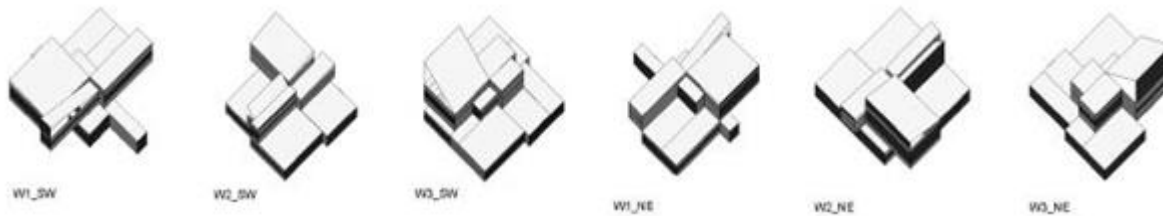Figure 4: The best answer for problem solving

Figure 5: The worst response to problem solving

5. Conclusion

One of the issues facing today's architects, quantity of information and increasing complexity of many architectural projects. Architects recently begun to use genetic algorithms as a tool for optimization have. This paper describes the architecture of genetic algorithms Dvgan٠ function: as a tool to optimize the tool for creating forms. These two functions are called, respectively, Necessity and desire. Dual function of genetic algorithm in this paper describes the architecture. That serve primarily as a tool to optimize the reality. In addition to the optimization function can also utilize genetic algorithms to create innovative forms. More recent work has served the world. This paper also examines the reasons for using genetic algorithms.

One of the striking features of genetic algorithm, its ability to perform various process parameters and design. Considering the relationship between these parameters. Means that the genetic algorithm is able to design a process that can lead to the answer to satisfy the parameters defined in the acceptable range. Genetic algorithms are successfully used in some construction projects have been including the 2008 Olympic water sports center in China pointed out. Genetic algorithm as a random process for solving search and optimization problems, which makes thousands of repeats in one second And finds a set of solutions, the designer's mind opens to the world of the unknown and unimaginable complexity. However, genetic algorithms, the potential future role in the architecture is more efficient.

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