

MODELLING OF DECISION-MAKING FRAMEWORK FOR SELECTION TECHNOLOGICAL ADEQUACY SYSTEM MEDIA FAÇADES

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Abstract

In recent years, media façades have become a new architectural theme and numerous potentials and limitations are observed in their design process and implementation. This paper identifies the most important challenges in the design of a media façade in order to define the basic criteria that influence decision making in the selection or the fulfillment of the most important principle – the adequacy of technological process of a media façade design. The main method used in the paper is mathematical modelling. The result of this study is operationalization, putting into operation the design knowledge and design principles and the construction of media façades, with the algorithm and software as the outcome that can become a tool in the process of media façade design taking account of specific variables and unchangeable parameters. The most important contribution of this paper is to present the practical application of software for checking the technological adequacy of media façades, of certain technical characteristics, taking into account a set of real urban and architectural conditions of the building and the location in design of new or reconstruction of old buildings.

Streszczenie

W ostatnich czasach fasady medialne stały się nowym tematem architektonicznym, w którym zauważa się wielki potencjał, ale także i wiele ograniczeń zarówno w fazie projektowania, jak i wykonawstwa. Nieniejszy artykuł wskazuje najważniejsze wyzwania projektowania fasad medialnych w celu zdefiniowania podstawowych kryteriów wpływających na proces podejmowania decyzji w zakresie wyboru lub spełnienia najważniejszej zasady – prawidłowości procesu technologicznego projektowania fasady medialnej. Główną metodą wykorzystaną w tym artykule jest modelowanie matematyczne. Rezultatem prowadzonej analizy jest operacjonalizacja – tzn. praktyczne wdrożenie wiedzy projektowej i zasad projektowania oraz konstruowania fasad medialnych poprzez opracowanie algorytmu i stowarzyszonego oprogramowania będących narzędziem w procesie projektowania fasad medialnych przy uwzględnieniu parametrów stałych i zmiennych. Najistotniejszym wkładem tego artykułu jest prezentacja praktycznego zastosowania oprogramowania do kontroli poprawności technologicznej fasad medialnych o zadanych charakterystycznych technologicznych biorąc pod uwagę zbiór rzeczywistych warunków miejskich i architektonicznych budynku jak również lokalizacji nowo projektowanych bądź rekonstrukcji istniejących obiektów.

Keywords: Design principles; Design process; Media architecture; Media façades; Technological adequacy; Variables.

1. INTRODUCTION

The development of architecture is followed by significant changes in the design and the construction of architectural objects' façades, where one of the most important change of the twentieth century is "dematerialization" and transformation of a building envelope. Mies van der Rohe's "skin" is transformed into intelli-

gent "emotionalized system" of a media façade, which can be modified and altered according to information received from the external or internal environment.

Media architecture is a response to the transformed, constantly changing conditions in urban environment, which present a consequence of globalization, information and media technologies. Media architecture is

a social platform that serves for cultural experience presentations or for promotion of a new form of experience exchange in “relational space” [1].

Studies have shown that there are different interpretations of the basic preconditions under which the façade can be considered to be a media façade. The dynamism and changeability in the functioning of the façade are the most important criteria [2]. For other theoreticians the possibility of transposing messages (communication) is the only necessary prerequisite [3].

The rapid development of technology has resulted in numerous technical possibilities that are available to architects. Two large groups of media façades, mechanical and electronic ones, practically satisfy a wide field of designers' requirements, in terms of shape, size, spaciousness, colour, resolution, locating media elements within the façade, functioning, visual comfort and satisfaction of technical performances (the effect of temperature changes, wind and fire), as well as economic and energy sustainability. On the other hand, we should highlight the possibilities of architects to bring “innovation” themselves and propose customized technologies for specific objects that help avoiding uniform solutions.

If we take into account a very large number of available media façade technologies, we can see a big issue for designers, since it is not clear what it is that the media façade should fulfill in the technological, aesthetic and functional terms. On the other hand, the design of media façades cannot be done without the involvement of and harmonization of a number of different professions, such as architects, electrical engineers, developers, business managers/development managers, designers, experts in the sphere of film, production and video presentations, real estate managers, urban designers and planners, media technologists, media sociologists, psychologists and culturologists, thus making the process more complex.

The subject of this work is the creation of design framework of optimal technological systems of media façades.

The basic hypothesis of this paper states that through the process of checking and selection of modern systems of media façades we can respond to changeable and unchangeable criteria of an object and the context of media architecture in order to complete the integration of architecture and media content through different degrees of technical and technological adequacy.

The aim of this work is to improve the methodological results of previous research, i.e. the operationalization of technological adequacy as the most important principles for media façade design.

2. LITERATURE REVIEW

A large number of theoreticians and architects have been exploring the topic of media façades from different aspects: technology, programming and media façades content [2, 4, 5, 6]; interactivity [7]; the complexity of urban medialized space [1, 8] and media culture through media façades [9, 10], which can be seen in Table 1.

Table 1.
Media façades and bibliographic review

Autor(s)	Highlights
McQuire, S. [1] Fatah, A. [8], Pop, S., Stalder, U., Stuppek, M. [9], Brynskov, M., Dalsgaard, P. [10]	Social/cultural parametres
Diniz, N.V., Duarte, C.A.[11] Brignull, H., Rogers, Y. [12]	Psychological parametres
Moere Vande, A., Wouters, N. [13]	Environmental parametres
Tschearteu, G. [5], Kronhagel, C.[6] Fritsch, J., Dalsgaard P. [14]	Holistic approach
Haeusler, H. [2, 4] Halskov, K., Ebsen, T. [15]	Technical parametres

Certain authors [8] consider that “currently there is no complex methodology for media façades’ design as an integral part of urban environment” in the world of architectural theory and practice, although it is emphasized by *Huang and Waldvogel* [16], who offer a wide and abstract range of design principles and do not present specific guidelines in sufficient way. These authors specify four general ideas that have to be realised during media object design:

- Highlighting spaciousness, rather than object components,
- Physical and virtual flexibility,
- Distraction,
- Physical and virtual privacy and personalization.

The starting point for media façade design is terminology and classification system. Basic terms, media façade attributes that can be found in the literature are the following: display technology, image properties, integration, permanency, dimensionality, translucen-

Table 2.
Classification of media façade systems by technical category, according to Haeusler [2]

Technology	System	Subsystem
Technology of projectors (CRT, LCD, DLP, LcoS projectors)	On the front of a façade	
	On the back of a façade	
Technology of illumination (LED, by fluorescent lights)	Lighting elements of illumination	
	Animation technology in a raster of a façade division	
Screen technology (LED, TFT, LCD, plasma)	LED lighting integrated into glass (insulating/laminated in glass façades)	<ul style="list-style-type: none"> – LED lighting integrated in the basic sub-construction of a glass façade (MiPix 20® technology, Instalight 4025 I 2019® technology) – LED lighting integrated into additional sub-construction of a glass façade (STELTH TM technology) – LED integrated into a dotted sub-construction of a glass façade (Punktum ® lux) – LED integrated into a steel mesh (Mediamesh®, Ilumesh® iDotmesh® technology)
	“Transparent façades”	
	“Non-transparent façades”	
	ETFE polymer and integrated LED lighting	
	Three-dimensional media façades (Voxel® technology)	

cy, sustainability, content, interaction, socio-urbanistic properties and artistic qualities [5]. On the other hand, the classification of the media façades is complex, taking into account the large number of available systems, which are constantly improving and changing. The most important criterion of media façade systematization is technical and technological category and provides a comprehensive classification [4]. *Haeusler* divides a media façade into mechanical and electronic media façades. Electronic media façades, as a dominant group, include the following technologies: a projector, an illuminator, a display and customized technology. By the analysis of different systems that the author refers to, electronic media façades can be classified according to Table 2.

The principles of programming, the level of interaction and connection types that are achieved among the actors are also of particular importance for the design of media façades [6]. Media façade, i.e. its content, can be programmed as: auto-active, active, reactive and interactive.

For some authors, media façades represent “exponents of decisive constraints” [17]. They feel that media façades can be seen as “digital artefacts, public interfaces, interactive spaces, items of ubiquitous computing”. From that point of view, for them, the design of the media façade presents a complex dynamism of creative limitations (decisive constraints) – 1: radical decision-making, 2: creative turning points. *Halskov and Ebsen* [15] also deal with the conceptual framework and challenges in the design of a media façade, but primarily in terms of presenting the contents of a media façade in accordance with the resolution, size, and pixel quality (colour, intensity) of artificial light.

Korsgaard et al. [18] define recommendations for media façades design, based on the experience of a complex project for underground station Odenplan in Stockholm in Sweden. *Process Reflection Tool* is a tool whose aim is defining steps in the process of media façade design.

Vande Moere and Wouters [13] emphasize the importance of three parameters related to the context of media façades as the key characteristics of mediaarchitecture: socio-demographic (environment), technical (content of displays) and architecture as a carrier that a medium has to support. When it comes to architecture as a parameter, the authors give special emphasis to the principle of media architecture integration in the physical and social terms. *Diniz et al.* [11] deal with the issues of interactive media façades and into their focus they place observers, perception conditions and in this regard they provide four key characteristics that differentiate media façades from urban digital displays:

- Integration with architectural building, in relation to *Tscherteu* [5] and *Schoch* [19];
- Space interaction, with special emphasis on social space and potential interaction space;
- Scale, which causes different behaviors of people accordingly;
- The effect of brightness, weather, traffic, and the environment, in relation to *Schoch* [19]

Similarly to *Diniz* [11], *Brynskov* [10] deals with the problem of interactive façades and the process of interaction of a media façade is divided into three stages: initiation, model (style) of interaction and relations. The most important, according to this author, are social interactions that are realized within the same social group or with unknown actors.

Similarly to afore-mentioned authors, *Brignull and Rogers* [12] deal with the problem of activation of participants in the public space in order to generate new

activities in the area of media architecture. The main theme is design and public interactivity planning, but they also investigate social barriers in humans. Other authors, like *Bilda* [20], *Maier* [21], *Bullivant* [7] also deal with the problem of interactive space design and media architecture as an integral part.

Fritsch and Dalsgaard [14, 22] are focused on the challenges imposed in the processes of design and media façade functioning and they state eight most important ones:

1. *The new interface-urban setting prompt new forms of interfaces or assemblies' alternatives and uses of existing ones.*
2. *Integration into physical structure and surroundings: new installations and systems must be integrated into existing physical surroundings.*
3. *Increased demands for robustness and stability: Taking into account the influence of climatic conditions, natural light.*
4. *Development of media content: exploration of how content affects the display façades and forms of interaction in space.*
5. *Well-balanced relationship with the actors (stakeholders): balancing off different interests.*
6. *The diversity of situation: research, meeting the most various possible situations that are developed on a spot as a result of the functioning of the media façade.*
7. *The transformation of social relations in space: jamming, imposing new forms of communication.*
8. *Adequacy and use of the city system (places and system).*

Table 3.
Design principles of media façade

Principles	Explanation
1. technological adequacy	applied technologies of media façades by their technical characteristics should be in compliance with both changeable and unchangeable variables of the surroundings and the object
2. integration	integration of media elements, information technologies and architecture in the context of a form, function and construction
3. visual changeability of a façade	constantly changeable perception in the function of time
4. energy sustainability	possibility of media façades to be potential generators of electricity or a system that influences the power consumption in an affirmative way
5. communication with the environment	architecture as a medium, communicational carrier in the function of realisation of bidirectional and multidirectional communication
6. stimulation of development	stimulation of the quality of constructed space, the improvement of social, cultural, economic development of an urban space, a city and a society
7. recognisability, originality of expression	avoiding uniformity, as an undesirable consequence of finished technological systems
8. protection	of existing architectural values during the transformation of older buildings' façades

Defining principles for media façade design in the form of a framework for media design enables high-quality integration of most of the aforementioned focus of different authors – media, new technologies and architecture [23]. Principles can have application in the design of new buildings, but also in the process of transforming the façade at the existing facilities. The authors pose the principles as general, taking into account that each designing case is the case for itself and media façade design should take place freely and not too determinedly. The mentioned principles should be taken as the “minimum set of standards” that well-designed media façade should meet (Table 3).

After analyzing the literature, we concluded that a significant room remains open for further defining the framework for media façades design. Though, on the one hand in the theoretical sense, there are numerous theories about media façade design, the variety of systems in technical sense as well as the complexity of the individual conditions of buildings and sites, the process of selecting adequate technological system are quite complex.

Compared to the previously mentioned literature, the main contribution of this work is a set of criteria to be included in the process of selecting appropriate media façade technology, which is a clear framework in decision-making process, for the actors that do not need to be fully familiar with the technical performance of most systems. Through the presented application the processes of selection and control are quick and easy.

3. METHODOLOGY

In this study we used the following research methods:

- The conceptualization of problems and research subjects is based on finding and analyzing the content of previous scientific research (literature review) on this issue;
- The collection of facts and their systematization on the most important research system’s characteristics of media façades in order to form an adequate database;
- Mathematical modeling as a method of operational research is used in the paper to create the algorithm (the sequence of some basic logic operations) and MediaLab software, which will serve as a tool in making optimal decisions in media façade design taking into account specific variables and unchangeable parameters.

Operation research consisted of three main phases:

1. The creation of a mathematical model of the research subject,
2. Algorithm development, production and testing using the method of object-oriented programming based on the collected baseline data,
3. Audit, verification of the proposed program that occurred during the second stage as explorative approach-research through design.

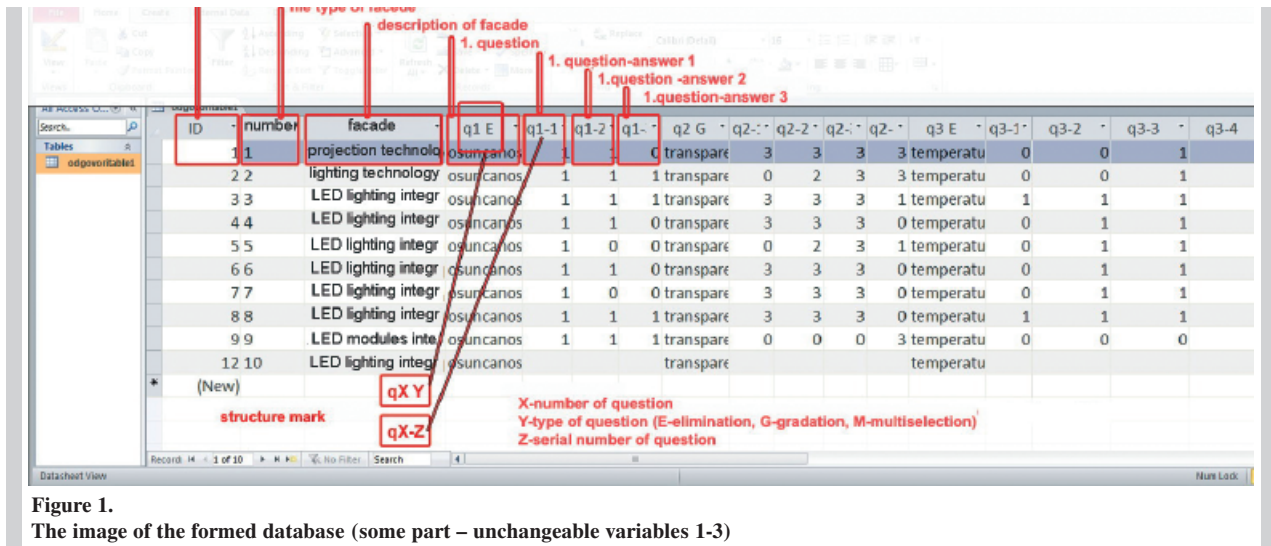
The software test case was The Belgrade Palace, Serbia. This test enables the analysis of its practical application. The application process itself consists of four decision types while selecting the most adequate system:

- *Deterministic* – probability of their selection is complete;
- *Probable* – realization depends on decisions made by designers under the given circumstances;
- *Statistic* – the least probability regarding the proposal order;
- *Eliminatory* – probability of their choice is zero.

4. RESULTS

The result of this paper is the system MediaLAB, as a form of subject-matter knowledge. MediaLAB is written in the Visual Studio programming language in Visual Basic, Windows platform, Microsoft Windows 7 optimization. The program is open. Since the software is based on the current subject-matter knowledge, which keeps being changed and modified in accordance with the latest media façade technological achievements, the system needs to be periodically upgraded.

The program is meant for the architects interested in media façade design. The objective of the program is to facilitate understanding of the available and possible media façade systems for those designers who are not so familiar with media façade field. MediaLAB is supposed to offer the list of the most efficient technological systems of media façades, based on the inputs (changeable and unchangeable variables) previously analyzed by designers (see the algorithm 1, Fig. 1). The program searches the most suitable system made of specific technical features. The software offers the output in form of a gradation list consisting of one or more of media façade systems that are seen as the most efficient for a specific case. The program does not provide ready-made design solutions but directs decision-making processes so that a designer could reach a final solution by combining and applying other design principles.



The use of MediaLAB software implies a previously performed evaluation analysis of the initial parameters made by designers for a specific location and building. It also includes the program requirements regarding a specific media façade. The user applies the program by marking one or more of offered options (depending on a question) for each offered parameter.

Software MediaLAB is based on a formed database (see the description of the base in Fig.1, system evaluation in Table 5a and 5b), consisting of the following media façade technologies:

1. front and rear projection technology,
2. lighting technology – lighting objects,
3. lighting technology – raster animation technology in façade division,
4. LED lighting integrated into multilayer glass applied to glass façades,
5. LED lighting integrated into additional subconstruction of façades,
6. LED lighting integrated into aluminum profiles of glass façades,
7. LED lighting integrated into dotted subconstruction of glass façades,
8. LED lighting integrated into steel mesh,
9. LED moduls integrated into façades,
10. LED lighting integrated into plate materials (stone, composite materials, etc.).

This list includes the most frequently used technologies. The base is not final; it can be extended by entering new data regarding façade systems. Also, the features of the already entered systems can be modi-

fied in accordance with their technological development.

Database formation is based on evaluation of media façade systems, in accordance with the established parameters and variables. The parameters are divided into two groups (see the algorithm illustrated in Fig. 2):

1. Unchangeable (the ones a designer cannot control),
2. Changeable (variables that a designer can control in accordance with his decisions).

Unchangeable variables:

1. Cloudiness/sunlight,
2. Object function and light comfort requirements,
3. Environment temperature (minimum and maximum values)
4. Air pollution level,
5. Building orientation and cardinal directions,
6. Ideal observation distance,
7. Observation angles,
8. Influence of surroundings and context,
9. Building design phase.

Changeable variables:

10. Façade type,
11. Shape and spatial configuration of a building,
12. Media façade position within the building,
13. Façade dimensions,
14. Operating mode,
15. Media contents presentation,
16. Types of media contents and motivation,

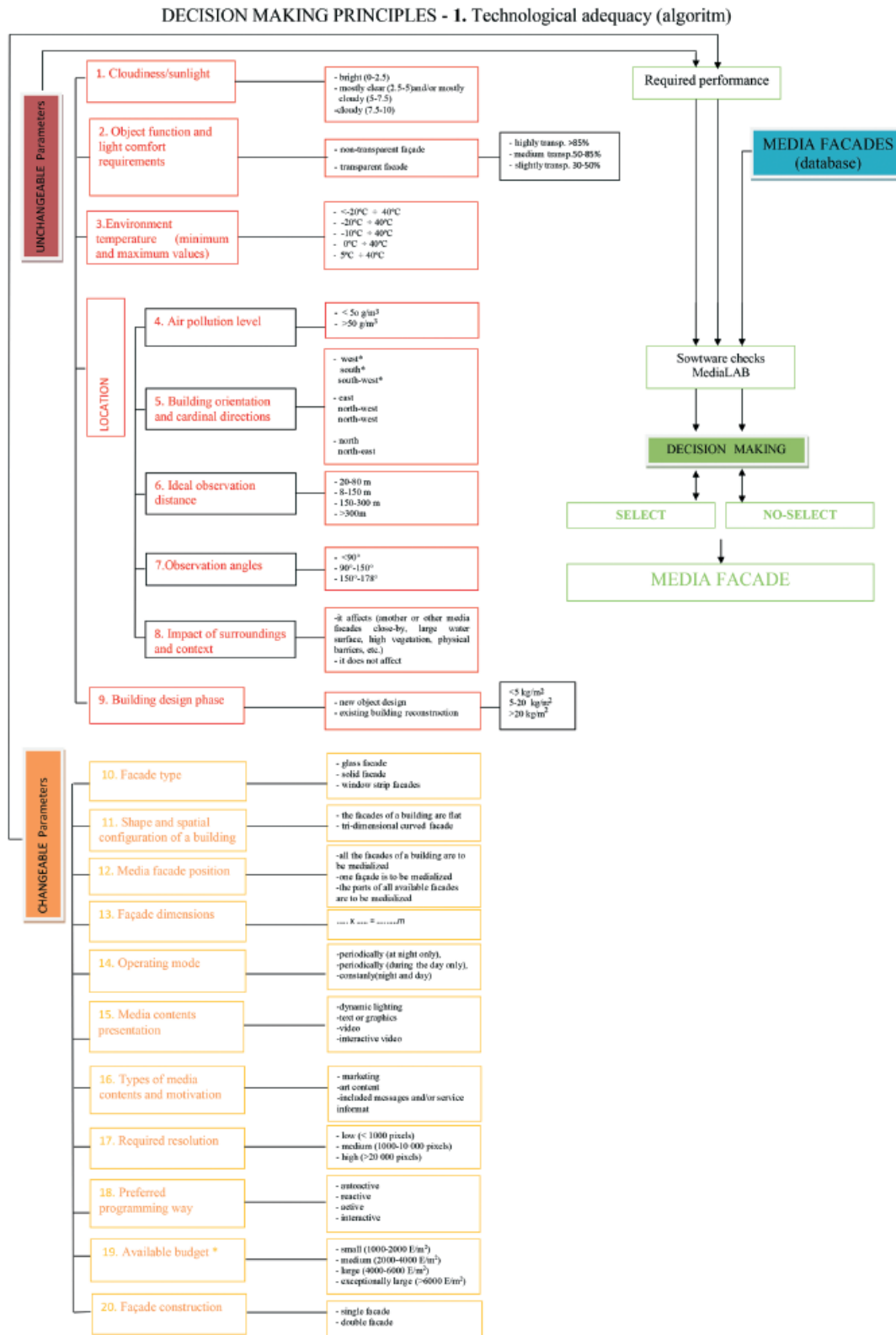


Figure 2. Algorithm

17. Required resolution,
18. Preferred programming way,
19. Available budget,
20. Façade construction.

Each proposed criterion is formulated by referent values in order to perform façade estimation (see the algorithm illustrated in Fig. 2) and these values are entered into the program base.

Parameter no. 1 – cloudiness, the average degree of covering visible fractions of the sky with clouds. The estimated values of cloudiness are 0 (clear sky) to 10 (overcast). This parameter affects the level (intensity) of media façade illumination. Therefore, the systems supporting greater illumination intensity should be installed in the areas having a large number of sunny days. The program offers the following referent values:

- bright (0-2.5),
- mostly clear (2.5-5) and/or mostly cloudy (5-7.5),
- cloudy (7.5-10).

Parameter no. 2 – function of the building. Depending on the function of a building it is necessary to design a façade that meets all functional requirements regarding the penetration of daylight into the building. The following options are offered:

- Non-transparent façade (there are no functional requirements regarding unobstructed penetration of daylight into the building),
- Transparent façade (there are functional requirements regarding unobstructed penetration of daylight into the building):
 - 1-300 lux (slightly transparent),
 - 300-500 lux (medium transparency),
 - 500-750 lux (highly transparent).

Parameter no. 3 – temperature, thermal condition of a space in the form of temperature extremes. Referent values correspond to the range covering the functioning of most media façades:

- $< -20^{\circ}\text{C} \div 40^{\circ}\text{C}$
- $-20^{\circ}\text{C} \div 40^{\circ}\text{C}$
- $-10^{\circ}\text{C} \div 40^{\circ}\text{C}$
- $0^{\circ}\text{C} \div 40^{\circ}\text{C}$
- $5^{\circ}\text{C} \div 40^{\circ}\text{C}$

Parameter no. 4 – air pollution level implies the presence of soot and dust in the air, nearby the building itself. These particles can affect our perception of a building or interfere with the functioning and maintaining of mechanical media façades as well as the

components and equipment of electronic media façades. Values relate to annual average concentration. The program includes two referent values on the basis of measuring the quantity of solid particles over 24 hours in accordance with the prescribed limit values (50 g/m^3).

- $< 50 \text{ g/m}^3$ – pollution does not affect façades
- $> 50 \text{ g/m}^3$ – pollution that requires the application of those façades that are not affected by pollution

Parameter no. 5 – building orientation and cardinal direction, or in other words – the orientation of the façade that is to be medialized in case it is one façade, or more façades that are dominantly observed in case all of them are to be medialized. This parameter affects the intensity of media façade illumination. The following options are offered:

- South or south-west or west → very good façade illumination is required,
- East or north-west or south-east → good illumination is required,
- North or north-east → decent illumination is required.

Parameter no. 6 – ideal observation distance or distance from the media façade needed to visually detect the best quality of the presented media façade contents. The offered referent values correspond to the range covering the performance of most media façades:

- 20-80 m,
- 80-150 m,
- 150-300 m,
- $> 300 \text{ m}$.

Parameter no. 7 – observance angle is a horizontal position that enables good observance of a media façade within urban context. The offered referent values correspond to the range covering usual functional changes:

- $< 90^{\circ}$,
- to 150° ,
- to 178° .

Parameter no. 8 – impact of surroundings and context, detecting the presence of the factors that can affect media façade functioning and perception quality, i.e. the level and intensity of media façade illumination. Two options are offered:

- It affects (another or other media façades close-by, large water surface, high vegetation, physical barriers, etc.)
- It does not affect

Parameter no. 9 – the phase of media façade design.

There are two basic cases:

- New object design
- Existing building reconstruction:
 - The building is under protection → media façade implementation is not an option,
 - The building is not under protection → it is allowed to implement a media façade but the static stability analysis is to be carried out first:
 - Primary structure cannot be used for media façade implementation → all the façades are excluded
 - Primary structure can be used for media façade implementation in accordance with loadings:
 - < 20 kg/m²
 - 20-50 kg/m²
 - >50 kg/m²

Parameter no. 10 – façade type is the parameter that defines full and void ration on façades, transparent and non-transparent parts. Three typical cases are defined:

- Glass façade (façade covered with glass >50%),
- Full façade (façade is with or without opening, covered with glass < 50%),
- Window strip façades (façade has windows and parapets arranged in horizontal strips).

Parameter no. 11 – shape and spatial configuration of a building is a parameter that defines the form of a building. There are two typical cases:

- The façades of a building are flat,
- The façades of a building are tri-dimensional curved surface

Parameter no. 12 – media façade position within a building. There are three typical cases:

- All the façades of a building are to be medialized
- One façade is to be medialized,
- The parts of all available façades are to be medialized.

Parameter no. 13 – façade dimension is a parameter to be considered when one façade is to be medialized. This parameter is not included in the process of evaluation. It is used in order to define maximum observation distance in accordance with the formula. It is presented in form of a final measurement by the program:

Width (m) × height (m) × 5 = maximum observation distance (m)

Parameter no. 14 – functioning mode is a parameter connected to durability of media façade performance. There are three typical cases:

- Periodically (at night only),
- Periodically (during the day only),
- Constantly (night and day).

Parameter no. 15 – media contents presentation are parameters related to conveying specific media messages by using some common presentation forms. Façades are to be analyzed in order to define their ability to support these presentation forms:

- Dynamic lighting,
- Text or graphics,
- Video,
 - Interactive video.

Parameter no. 16 – type of media contents that conveys messages through media façades. The following contents are offered:

- Marketing,
- Art content,
- Included messages and/or service information.

Parameter no. 17 – required resolution (number of pixels that create a media façade) is a parameter that is determined by a specific type and category of media contents. Referent values are the following:

- low (< 1000 pixels),
- medium (1000-10000 pixels),
- high (>20000 pixels).

Parameter no. 18 – preferred programming way, that is, the concept of preparing, programming, presenting and directing media contents is defined by software and conditioned on operating modes, types and forms of the presented media contents. There are four possibilities:

- Autoactive (presenting previously prepared content),
- Reactive (presenting media content that is conditioned on information coming from the immediate surroundings of a building),
- Active (“live” media content presentation),
- Interactive (media content is presented through connecting with the objects of one or more persons, users).

Parameter no. 19 – available budget for investing into media façades is a significant parameter in practice. Still, it is not included in this version of the program

since it is not meant for commercial purpose but scientific research only. Suggested values are based on commercial market values of the system and imply the price per square meter for entire media façade including all the necessary installations that are to be used.

- Small (1000-2000 E/m²)
- Medium (2000-4000 E/m²)
- Large (4000-6000 E/m²)
- Exceptionally large (>6000 E/m²)

Parameter no. 20 – façade construction is a parameter that defines structural elements of façades. Media façades can be designed in the following way:

- Single façade (a building has only one sheathing defined by a specific form and structure; media elements are organized at the level of the structure or in front of it),
- Double façade (façade structure consisting of two coats separated by air space).

When forming the base, the system of various evaluation methods was established in order to evaluate façade systems (Table 5a and 5b) in relation to a specific parameter (Table 4):

- Elimination – façade evaluation is eliminatory process (rating is 0 or 1); if a certain media façade

system does not meet a parameter and is evaluated as 0, it will be excluded from the final choice; program users are allowed to select only one of the offered answers;

- Multiselection – façade evaluation is 0 or 1; program users are allowed to select more answers that are to be added;
- Gradation – evaluation is performed through a series of stages (gradation) in accordance with the scoring system 0-3; program users are allowed to select one of the offered answers.

In accordance with this evaluation system, a façade that is estimated as 0 in relation to any criterion, is to be eliminated when selecting that very criterion by program users. That façade is not to be included in the selection set consisting of potential façades.

Certain specific characteristics are modelled during the process of programming. The program is designed in the following way – if a designer decides to implement media technology in the space between a double façade and confirms that decision by answering the 20th question, criterion 3 – temperature, it will not affect the selection of a façade since it is of no importance. Also, there is a connection between the parameters 1, 5 and 8 (cloudiness/sunlit, cardinal direction orientation, impact of surround-

Table 4.
Classification of media façade systems by technical category, according to *Haeusler* [2]

PARAMETERS		EVALUATION METHOD		
		elimination	multiselection	gradation
U N C H A N G E A B L E	1. cloudiness/sunlight	•		
	2. function of a structure			•
	3. environment temperature (temperature of surroundings)	•		
	4. air pollution level			•
	5. cardinal direction orientation	•		
	6. ideal observation distance			•
	7. observation angles			•
	8. impact of surroundings and context	•		
	9. design phase	•		
C H A N G E A B L E	10. façade type	•		
	11. shape and spatial configuration of a structure	•		
	12. media façade position			•
	13. façade dimension			
	14. operating mode	•		
	15. media content presentation		•	
	16. media content types		•	
	17. required resolution	•		
	18. preferred programming ways		•	
	19. available budget	•		
	20. façade construction	•		

ings and context), which has already been explained before. The façade evaluation regarding these three parameters is performed in accordance with the rating that defines the quality and intensity of façade illumination (see the Table 5a and 5b).

Users are provided with the program consisting of a series of questions and offered answers that are to be done while using the program. These questions are opened by activating two separate program windows: one for unchangeable and another one for changeable variables (Fig. 9.a and 9.b). The list of necessary questions was made after the surveys filled out by clients trying to conceptualize the idea of media contents implementation, in global companies dealing with media façades (for example ag4®). Dragging the mouse over a specific parameter provides users with a detailed explanation of that very concept and all potential misunderstandings of an option are eliminated. As soon as the selection of the offered options has been done, users are given all the required characteristics a media façade is to meet.

Based on the selection of offered options for both sets of parameters, the software performs scoring and evaluation of all façade systems. In other words, each selected option is added specific values. The final result is a proposed solution to potential media façade systems. Solutions are classified in accordance with their score. The list of solutions to potential media façades, which is based on selected conditions, is located at the bottom of the window, in the form of a dropdown menu. The list is always active. The first three ranked systems are visible, which is a starting point for further design procedures.

There is no doubt that a series of analyzed cases and technologies confirmed that some parameters are more significant than others. The process of optimizing different technologies of media façades showed that parameters can be ranked 1-3 in accordance with their significance. This classification can either be activated or not at the very beginning of using the program. Such evaluation requires a high level of expert judgement. Regarding this study, the performed classifications were subjective, based on a thorough research of media architecture and knowledge-base formed by the researcher. More significant parameters were assigned higher values, in comparison to less significant ones. The following hierarchy was established:

- a) Parameters, first order variables – rate 3:
 - horizontal observation angle,
 - optimal observation distance,
 - impact of surroundings and context,

- temperature,
- design phase (static stability).

- b) Parameters, second order variables – rate 2:
 - cloudiness/sunlight,
 - function and visual comfort requirements,
 - façade construction,
 - façade type,
 - cardinal directions orientation
 - media façade position,
 - required resolution,
 - programming ways,
 - content presentation,
 - required media contents.
- c) Parameters, third-order variables – rate 1:
 - air pollution,
 - operating mode,
 - shape, spatial configuration.

The conducted research on media architecture and media façades confirmed that there is a reason to form such a list. From an architectural point of view, urban parameters (angles, observation distance, impact of surroundings and context) are regarded as the most important ones since their influence on media façade perception is the greatest. From a technological point of view, the main difference between media façades is seen in their ability to emphasize all conditions of a location. Static stability, i.e. ability to bear the load of media façade construction, ensures the entire structure safety and is also one of the most important parameters, when it comes to reconstruction of old structures.

Everything regarding media façade functions, i.e. its contents (programming, presentation, types, resolution, light intensity), belongs to the second order variables. Also, there is a constructive aspect that is to be included in the contents (façade structure and type).

The third order variables include the aspects directly connected to media façade maintenance (air pollution impact, operating mode). Low maintenance is a very significant aspect. Still, while doing this research paper, it turned out that media façades are effectively maintained. Lately, a lot of effort has been put into improving their resistance to external influence. Since this is about the façade that implies a substantial financial resources in order to be properly implemented and maintained, this criterion is directly connected to the budget. Shape and spatial configuration of façades should not be a dominant inhibitory factor included in making design decisions.

The final interface of the program is visible through two offered options: unchangeable and changeable variables (Figs. 3 and 4).

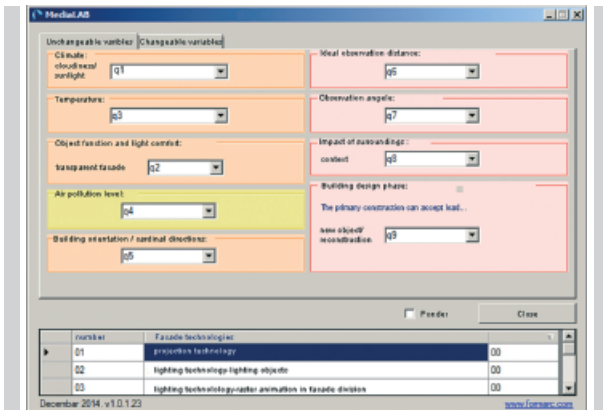


Figure 3. Unchangeable variables

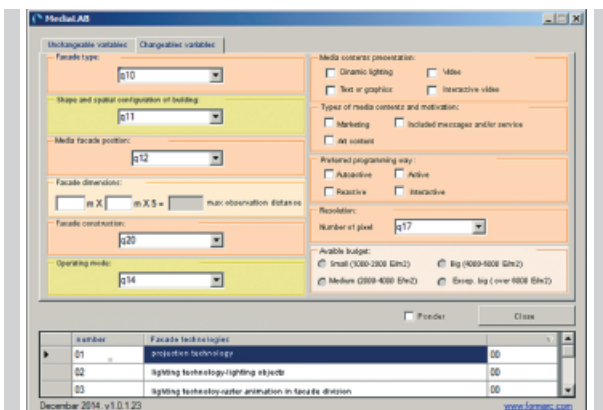


Figure 4. Changeable variables

4. PROPOSED MODEL VERIFICATION

Software verification and potential flaw detection were carried out during the process of designing and remodeling the existing glass façade of the Belgrade Palace in Belgrade, Serbia (built in the period 1969–74). The Belgrade Palace consists of two parts: one is shorter, more massive and aligned with the floors of neighbouring buildings, (P+4 and P+5), and the other part of the tower consists of 24 floors, which is why it is one of the most significant benchmarks of Belgrade. Trade and business are dominant functions of the building itself. Neighbouring buildings are mostly related to trade and business as well. It was necessary to make the whole building more attractive by stimulating urban development of both this area and entire city, considering a great visibility of its glass façade (Fig. 5).

What was characteristic for this building was double analysis in terms of angle observation and optimal observation distance. In other words, it is possible to analyze the shorter part of the building in one way,

and the other part of the building in a completely different way.

The east façade of the shorter part of the building used to be regarded as a very attractive place for commercial lease and billboards. Optimal observation distance is 300 m, based on field observation. The observation angle is 15° for long distance and 90° for immediate environment up to 80 m. The observation angle for the tower is 100°, optimal distance is 300 m. Maximum observation distance is up to 3500 m (Fig. 6). The building is inefficiently illuminated and indistinct at night.

The main principle of media façade design – technological adequacy, was tested by previously made software. As a result of this analysis, a potentially most



Figure 5. Belgrade Palace tower, detail of glass façade



Figure 6. The Belgrade Palace, observation angle 15°/90°

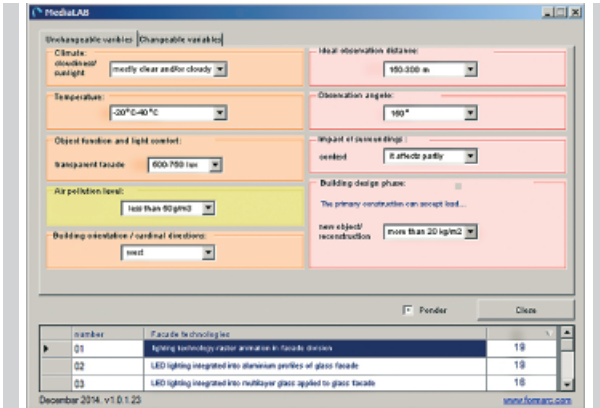


Figure 7. Unchangeable variables, MediaLAB – software optimization, The Belgrade Palace

optimal technology for the south-east façade of this building is LED lighting integrated into a steel mesh or multilayer glass. The best solutions to entire building medialization were also provided by this software – the first one is a media façade with LED lighting integrated into aluminum profiles, the second one is raster animation technology in the façade division (see Figs. 7 and 8).

The above suggested solution to remodeling the Belgrade Palace façade implies a double analysis of the same building, based on its volumetry and numerous floors. All its façades are planned to be medialized by implementing LED lighting, vertically positioned on the supporting subconstruction of an exterior curtain wall. In this way, the existing façade division will not be deranged. Such façade would operate at night, and its appearance would be unchanged during the day (Fig. 9).

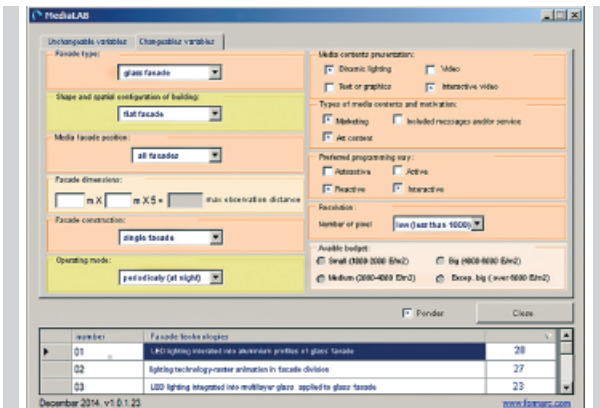


Figure 8. Changeable variables MediaLAB – software optimization, The Belgrade Palace

The application of high resolution to the whole building is economically unacceptable. Therefore, there is another option – only the front façade of the shorter part of this building is to be designed as media façade with RGB LED integrated into high resolution steel meshes and direct lighting. The mesh is to be placed in front of the existing façade, without disturbing the functioning of this building. This media façade would operate day and night.

Two programming types are planned: interactive, through touchscreen, meant for the façade with LED lighting integrated into steel mesh, and reactive, meant for all other parts of façades (mediamesh®).

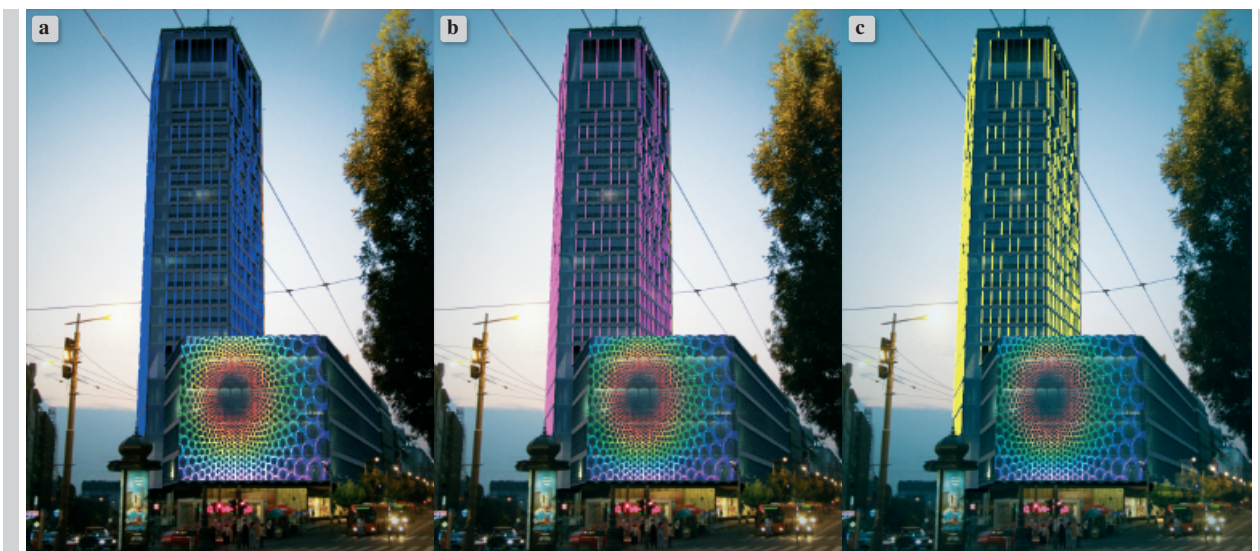


Figure 9. Media façade – The Belgrade Palace

Table 5a.
Unchangeable parameters – verification of media façades technologies

Type of façade	ques- tion	1, 5, 8→ Brightness intensity			2			3			4		6		7		9							
	answer	low<1000 cd/m ²	Good <1000-3000cd/m ²	Vary good >3000cd/m ²	High transp. >85%	Medium transp. 50-85%	Low transp. 30-50%	notransparency	<-20°C-40°C	-20°C-40°C	-10°C-40°C	0°C-40°C	5°C-40°C	<50 g/m ³	>50 g/m ³	20-80 m	80-150 m	150-300 m	<90°	90°-150°	150°-178°	<5 kg/m ²	5 -20 kg/m ²	>20 kg/mV
1.	1	1	1	0	3	3	3	3	0	0	1	1	1	1	2	3	2	1	3	2	0	1	1	1
2.	1	1	1	1	0	2	3	3	0	1	1	1	1	1	1	1	3	2	3	2	1	0	1	1
3.	1	1	1	1	3	3	3	1	1	1	1	1	1	1	2	1	3	2	3	2	1	1	1	1
4.	1	1	1	1	3	3	3	1	0	1	1	1	1	1	2	3	2	1	3	2	1	0	0	1
5.	1	1	0	1	2	3	1	0	1	1	1	1	1	1	1	1	3	2	3	2	1	0	1	1
6.	1	1	0	3	3	3	1	0	1	1	1	1	1	1	2	1	3	2	3	2	0	0	1	1
7.	1	0	0	3	3	3	1	0	1	1	1	1	1	2	3	2	0	3	2	0	0	0	1	1
8.	1	1	1	2	3	3	2	1	1	1	1	1	1	1	2	3	1	3	2	0	0	1	1	1
9.	1	1	1	0	1	3	3	0	0	0	0	1	1	2	3	2	0	3	2	1	0	1	1	1
10.	1	1	1	1	0	1	3	3	1	1	1	1	1	1	2	3	3	2	3	3	2	0	1	1

Table 5b.
Changeable parameters – verification of media façades technologies

Type of façade	ques- tion	10		11		12		14		15		16		17		18		20											
	answer	Glass façade	Full façade	Window strip façades	The façades are flat	The façade are tri-dimensional curved	All the façades of a building	One façade	The parts of all available façades	Periodically (at night only),	Periodically (during the day only),	Constantly (night and day)	Dynamic lighting	Text or graphics	Video	Interactive video	Marketing	Art content	Included messages and/or service information	low (< 1000 pixels)	Medium(1000-10000 pixels)	high (> 20000 pixels)	Autoreactive	Reactive	Active	Interactive	Single façade	Double façade	
1.	1	1	1	1	1	3	3	1	1	0	0	1	1	1	0	1	1	1	1	1	1	1	1	1	0	0	1	0	
2.	1	1	1	1	1	3	3	3	1	1	1	1	1	1	0	0	1	1	0	1	1	0	1	1	1	1	1	1	1
3.	1	1	0	1	1	3	3	1	1	1	1	1	1	0	0	1	1	0	1	0	0	1	1	0	1	1	1	1	1
4.	1	0	0	1	1	3	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5.	1	1	1	1	1	3	2	3	1	0	0	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1
6.	1	0	0	1	1	3	3	1	1	0	0	1	1	0	0	0	1	0	1	1	0	1	1	1	1	1	1	1	1
7.	1	0	0	1	1	3	3	1	1	0	0	1	1	0	0	0	1	0	1	0	0	1	1	1	1	1	1	1	1
8.	1	1	1	1	1	3	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
9.	0	1	1	1	1	2	2	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
10.	1	1	1	1	1	3	1	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

- 1. projection technology;
- 2. lighting technology – lighting objects;
- 3. lighting technology – raster animation technology in façade division;
- 4. LED lighting integrated into multilayer glass applied to glass façades;
- 5. LED lighting integrated into additional subconstruction of façades;
- 6. LED lighting integrated into aluminum profiles of glass façades,
- 7. LED lighting integrated into dotted subconstruction of glass façades;
- 8. LED lighting integrated into steel mesh;
- 9. LED moduls integrated into façades;
- 10. LED lighting integrated into plate materials (stone, composite materials, etc.)

5. DISCUSSION

When it comes to the hypothesis set at the very beginning of this paper – creating a frame for media façade design is required in making decisions on selecting the most appropriate technological system to meet most criteria and contexts of media architecture, the result of this paper is the software tool MediaLab, the one that makes it possible. The software covers the process of media façade categorization, provided by other authors [2]. Also, the parameters, which were taken into consideration, are almost aligned with the technical attributes that *Tscherteu* [5] regarded as classification focus. According to him, technical characteristics are of crucial importance for “visual experience”, interactivity and “urban value” of media architecture:

Certainly a more refined technical understanding will be helpful for developing a more differentiated attitude to media façades.

Technological adequacy, i.e. media façade technology whose characteristics are in accordance with environment, carrier and content [13], is one of the most significant principles of media façade design. However, scope and complexity of this principle imply a clear and precise hierarchy in decision making processes.

Compared to *Tscherteu* [5], who pointed out eleven important criteria (display technology, image properties, integration, permanency, dimensionality, translucency, sustainability, content, interaction, socio-urbanistic properties and artistic qualities), this paper takes into consideration an extended list of twenty criteria. These criteria are divided into two groups: changeable and unchangeable variables. Criteria gradation is performed by pondering.

The most important advantage of this MediaLab software is its ability to quickly perceive a significant number of media façade systems, the ones that do not necessarily have to be familiar to designers. On the other hand, all those systems that do not meet the established requirements are eliminated, which significantly reduces all design activities. As it has already been shown, only two urban parameters (observation angle and observation distance) are enough to change the system adequacy completely. As for the software optimization, available budget is not active as a changeable criterion, since it is about a non-commercial purpose. When it comes to practice, available budget is of crucial importance and it needs to be included in the first order criteria. Commercial conditions are changeable and depend on numerous factors (media façade size, new structure/reconstruction, location characteristics during the implementation process, etc.).

The performed test revealed some software flaws, which implies its further upgrade. Since this program is based on the principles of mathematical modeling, it can still have some defects, because of the fact that qualitative characteristics in architecture cannot always be expressed in a quantitative way. The program deals with standard situations during the process of design and such situations are rather rare. If the location itself is specific or investors require special demands, which means that one evaluation criterion is predominant in comparison to other criteria, the established hierarchy of parameters fails to support the case. Software upgrade means that one should always ensure that the hierarchy within the program itself, established by pondering, can adapt to such demands. In other words, it is possible to change these ponders, depending on the case itself.

One of the possibilities to upgrade the software is to create an open advanced version that can be upgraded by users themselves. Another possibility is to create a software that is available on-line. It can be useful in the field of virtual cooperation, since this type of service means that database is open for new systems and media façade technologies, as well as for potential changes of the existing technical characteristics. It should also be pointed out that the base of available media façade systems can be extended in accordance with constant and rapid technological changes.

6. CONCLUSIONS

The most important contribution of this paper, regarding practice improvement in the field of architecture and urbanism, is a consolidation of previous media façade suggestions into the software checking technological adequacy of media façade systems, for specific conditions of location and structures. The program was verified and tested through the case of an important building in Belgrade, Serbia.

Software MediaLab can be used in the process of media façade design, for both new and old buildings. The main purpose of this program is to be the starting point for the architects who are not so familiar with available systems of media façades. The program directs decision-making procedures by eliminating the media façade systems whose performance is not suitable for a certain location and does not meet the established design requirements. This program facilitates the process of design, especially if a designer does not have enough time to become familiar with all important systems. Software Media Lab does not offer design solutions; it only deals with the most significant

urban parameters and design requirements in order to optimize the ten existing media façade systems included in its base. The final result is possibility map, i.e. gradation list of the most optimal applicable systems of media façades that a designer is supposed to use in a creative way.

The program also reveals certain flaws regarding the limited system base. Therefore, its further upgrade and continual upgrade is necessary.

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