MINISTERUL EDUCAȚIEI

UNIVERSITATEA TEHNICĂ DIN CLUJ-NAPOCA

Domeniul

TEZĂ DE DOCTORAT

– REZUMAT –

Codul sonor al spațiilor urbane
Identitatea piețelor redată prin sunet

Student-doctorand:
Mihai RUSU

Conducător științific:
Conf.dr. habil.arh. Dan-Ionut JULEAN

Comisia de evaluare a tezei de doctorat:

Preşedinte: Prof. Dr. Ing. **Prenume Nume** - Universitatea Tehnică din Cluj-Napoca;
Conducător ştiinţific: Prof. Dr. Ing. **Prenume Nume** - Universitatea Tehnică din Cluj-Napoca;
Referenţi:
- Prof. Dr. Ing. **Prenume Nume** - Universitatea ……………………………………………………………………. ……………………………………………...;
- Prof. Dr. Ing. **Prenume Nume** - Universitatea ……………………………………………………………………. ……………………………………………..;
- Conf. Dr. Ing. **Prenume Nume** - Universitatea …………………………………..……………………………. …………………………………………… .

– Cluj-Napoca –
2025

str. Memorandumului nr. 28, 400114 Cluj-Napoca, România
tel. +40-264-401200, fax +40-264-592055, secretariat tel. +40-264-202209, fax +40-264-202280
www.utcluj.ro

CONTENT

1. Purpose and objectives of the researched doctoral thesis

The theme of the present work was born from the increasingly pressing need to produce a tool, a methodical line for the design, planning of architectural spaces in a visual-sound tandem. The attractiveness of an urban open space is ensured by several important factors such as the existence of attractors of different types (economic, cultural) but also by ensuring an attractive visual and sound comfort. The current tools of the architect are based on visual elements in the planning or re-ambulatory of open or closed spaces of architectural forms. With the social, economic development of society, the role of sound has become extremely important in anthropic or anthropized spaces. For this reason, the present study attempts to emphasize the importance of sound in the planning of architectural spaces and equally to establish conditions for the production, propagation and perception of sound depending on architectural factors of forms and spaces. In this sense, we built sound-visual planning benchmarks for the spaces subject to their planning and organization. The sound organization benchmarks for open spaces such as squares were established through an analytical line in which the ideological basis consisted of the principles of space syntax. On this support, with the help of the DepthMapX application, the spatial attributes of integration, connectivity, choice that make the transition to the type of behavior of dynamic or static users, behavior imposed by the visual perception of open spaces, were determined using the axial map, VGA, convex map application variants. The determined attributes were correlated with the form elements, operable by the architect, of the open spaces. The isophone maps made through repeated sound measurements on the example of four squares in Cluj-Napaoca (Museum Square, Union Square, Avram Iancu Square, Mihai Viteazu Square) were compared, correlated with the attributes mentioned above. The methodical end of this research chain was to correlate the form elements with sound values assigned to the components of axial maps (axial lines), spatial squares settable as real dimensions (in VGA analyses) or for convex spaces (determined according to the internal organization of the squares). The results of this procedural finality certified what at the beginning of the research was only at the stage of presumption. The presumption consisted in the existence of close correlations between the sound and the visual of open spaces and of the existence of spatial typologies that impose types of sonorities regardless of the source (as an energetic or informational message position).

2. Concrete objectives of the research carried out by the doctoral thesis

A first objective consisted in creating a bibliographic set on this topic of sound planning in open spaces usable by any specialized operator who deals with the organization of open spaces or their redevelopment in the case of an architect. The space researched in this work is a type of open space in the category of squares.

An open space is „...as a space in the urban environment that is readily available to the community regardless of its size, design or physical characteristics and that is intended primarily for physical development or recreation, whether active or passive”[1].

If the degree of accessibility is also added to the functions of open spaces, the diversity of open spaces increases and the specialized literature mentions open spaces such as: public parks, squares, memorials, streets, playgrounds, community open spaces, greenways and parks, atriums/interior squares, banks.

One of the most complex and comprehensive classifications is that of Carmona[2]. In this classification with various external classes, squares are part of the positive spaces. For the definition and critical analysis of open spaces, over 100 works from the international bibliography were studied, primarily (Romanian specialized literature is unfortunately poor on this topic), and less so from the Romanian one. The important names are those cited.
The theme of the present research uses urban squares as observation spaces. They are a category of open spaces specifically through functions, configurations and implicitly through the attributes of the square syntax.

The square is an important component of urban space (of the city image in Lynch's sense), civic space in Carmona's sense. The author's classification can include squares in the category of sectors with external and internal observation, in the category of nodes, defined by Lynch as „strategic places of the city......intensive poles to and from which the observer travels”[3]. For sectors, Lynch's formulation first mentions the role of sound as an identification factor, referring to Beacon Hill, saying: „the clues weren't just visual, noise was just as important ...”.The square is rightly considered a built environment that must produce activities that polarize the urban population but also provide a fusion between its physical features and social behavior. For example, according to Barlas[4]„horizontal surfaces support movement and locomotion; the combination of horizontal and inclined vertical surfaces can allow and provide shelter from the elements, concealment, and security". Social, political, and economic roles are played in squares [5]. In accordance with the above metaphor „Squares are physical voids that provide breathing space in the middle of buildings”[6] is extremely expressive in terms of the importance of urban squares for the entire urban texture.

---

[1] Rofe M. W., Kellett J., 2009, *Creating Active Communities: How Can Open and Public Spaces in Urban and Suburban Environments Support Active Living?58),* - „ca spațiu din mediul urban care este ușor disponibil comunității indiferent de dimensiunea, designul sau caracteristicile sale fizice și care este destinat, în primul rând, amenajării sau recreerii fizice, indiferent dacă este activ sau pasiv” (trad. ns.)
[2] Carmona, M., , *Urban design and planning practice*,
[3] Lynch, K., 1960, The Image of the City, 28
[4] Barlas, A., 2006, *Urban Streets and Urban Rituals*,56. - „suprafețele orizontale susțin mișcarea și locomoția; combinația de suprafețe verticale orizontale și înclinate poate permite și asigura adăpost de intemperii, ascunderea și securitatea” (trad. pers.)
[5] Whyte, W., , *City: Rediscovering the Center*, 89
[6] Zakariya K., Zalina Harun N. Z., Mansor M., 2014, *Spatial Characteristics of Urban Square and Sociability: A review of the City Square, Melbourne*, 12- “Pieţele sunt goluri fizice care oferă spaţiu de respiraţie în mijlocul clădirilor” (trad. pers.)

The specialized bibliography classifies squares according to different criteria. The present work, after a critical analysis of these classifications, adopted the types that allow the explicit analysis of the sound of these types of spaces.

A first classification refers to the functions of the squares ensured by the arrangement of the squares, the content of street furniture and/or art objects, the ratio between the occupied and free space in a square. So in other words, the spatial configuration produces types of activities. Jan Gehl groups these activities into three categories: necessary (they are relatively independent of the physical conditions of the urban environment), optional (depend on the physical conditions of public spaces) and social activities (they are closely correlated with the physical environment of public spaces) [7]. Another classification is that made according to the shape of the squares. Shape is a concept of stability, continuity[8]„ in time and affects memory by producing symbols. Space is perceived frontally and horizontally by the user, which is why he will evaluate the space of a moving square only up to the first level, noting only the order, coherence of the space and its sonority. The sitting position modifies the viewing angles. The order and coherence of space is given by the grouping or types of grouping of objects in a public square or any other space (Gestalt theory). The syntax of space used by us in this work as an ideological line is based on its perceptual use, of space. These perceptions do not include the height of buildings. And in this case the established bibliographic set is and will be an important source of documentation for future works on such a theme.

The bibliographic set useful for future works oriented on such a theme of sound design of open spaces also requires a bibliographic set with information related to sound studies of open spaces. In this sense, the quote that urges towards sound studies of open spaces is extremely exciting: :„For twenty-five centuries, Western intelligence has tried to look at the world. It has failed to understand that the world is not for spectators. It is for being heard. It is not legible, but sonorous. Our science has always wanted to monitor, measure, abstract and neutralize meaning, forgetting that life is full of noise and that only death is silent: the noise of work, man-made noise and the noise of wild animals. Noise has been bought, sold or banned. Nothing essential happens in the absence of noise. Today, our vision has blurred; we no longer see our future, having built a present made of abstraction, absurdity and silence. Now we must learn to judge a society more by sounds, by art and festivals, than by statistics. By listening to noise, we can better understand where the madness and calculations of people are leading us and what hopes it is still possible to have"Jacques Attali[9].

The bibliography in this sound field, so useful in the modern era for the architect planner, has several works of great value, an important name is that of Jian Kang. Essentially, the works found in the bibliographic list focused on this theme speak of sound fields, the acoustics of open spaces, soundscapes, the noise of open spaces or the sound perception of spaces such as squares. The perception of sound creates "atmospheres" which will give the

---

[7] Gehl, Jan, et al., *The Interface Between Public and Private Territories in Residential Areas,*12

[8] Psarra S., Grajewski T., 2011, *Describing Shape and Shape Complexity Using Local Properties,(* Welsh School of Architecture,2011),18

[9] Attali, Jacques. *Bruits. Essai sur l'économie politique de la musique*. (Paris: PressesUniversitaires de France, 1977),45-51 - „Timp de douăzeci și cinci de secole, inteligența occidentală a încercat să privească lumea. Aceasta nu a reușit să înțeleagă că lumea nu este pentru spectatori. Este pentru a fi auzita. Nu este lizibilă, dar sonoră. Știința noastră a dorit întotdeauna să monitorizeze, să măsoare, să abstractizeze și să neutralizeze sensul, uitând că viața este plină de zgomot și că doar moartea tace: zgomotul muncii, zgomot facut de om și zgomotul animalelor salbatice. Zgomotul a fost cumpărat, vândut sau interzis. Nimic esențial nu se întâmplă în absența zgomotului. Astăzi, vederea noastră s-a estompat; nu ne mai vedem viitorul, după ce am construit un prezent făcut din abstractizare, absurd și liniște. Acum trebuie să învățăm să judecăm o societate mai mult prin sunete, prin artă și festivaluri, decât prin statistici. Ascultând zgomotul, putem înțelege mai bine unde ne conduc nebunia si calculele oamenilor și ce speranțe este încă posibil să avem"

urban space its character of attractiveness or repulsion. The preferences of soundscape elements influenced people's choice to use an urban square, the finding belonging to the authors Wei Yang and Jian Kang[10] being another source that confirms the role of the perception and subjective analysis of sounds. In the architecture of open spaces Kamenicky[11] makes an important transition for the present work by stating that the soundscape, the sound is a „property", which differentiates architecture from other art forms. The acoustics of the designed space, whether it is interior architecture or the urban exterior of the public space, decisively influences their soundscape. [12] Various authors consider the soundscape as a landscape of aesthetic sounds (so we are talking about the effect of sound) and noise. We believe that noise can also be a symbolic element if it is permanent, regular. With this in mind, objective evaluation, sound intensity limits and normative acts that regulate such sounds come into play. In this paper, noise will be filtered because we do not believe that it can have a permanent character. But we must also insert here the opinion of one of the great composers of urban sound who, along with Varesse or Shaffer, is recognized as a pioneer in the field of soundscape, who said in a conference in 1937 (this is Page. I.). „Wherever we are, what we hear most are noises, and these noises bother us when we ignore them, but fascinate us when we listen to them." [13]. This statement urges us to be cautious when making subjective assessments of sound perceptions in the proposed case studies.

Bibliographic works can be grouped on important themes of the analysis of spaces such as squares, on sound sources, the way of transmitting sound depending on the spatial configuration of the squares, and on their perception. Sound in environmental analyses can be approached on several components as I said, namely: sound sources, sound transmission and factors that influence its transmission, sound perception. This last component has as systemic elements objective evaluation, subjective evaluation (influenced by sociological, demographic, psychoeducational factors, etc.), the human receptor (the system of reception and emotional processing of sound). Of course, a new question arises, namely which science would be entitled, through methodology and paradigms, to approach a research of environmental sound in general or even of the urban one. What Belgiojoso wrote goes towards approaches to architecture, the arts in general. But geographical, physical, etc. approaches are definitely possible. Since the 1960s, there has been increasing talk about the architecture of urban sound, with elaborate analyses, important conclusions and applications (transformed by John Cage and his disciples into art, for example). We believe that an interdisciplinary analysis would yield important results regarding sound, its production, perception and the environmental functions determined by the type of sound. But up to a certain level of analytical approachability, an instrument operable by the main operator in the re-ambulatory or planning of the squares is needed, and this is the architect.

Another proposed objective was to create analytical matrices on the model of the four Cluj squares analyzed that would demonstrate correlations between the shape elements and the attributes of the spatial configuration. Such an achievement was marked by the establishment of some shape characteristics of the squares such as: average length of the

---

[10] Wei Yang, Jian Kang, - *Soundscape and Sound Preferences in Urban Squares*, (School of Architecture, University of Sheffield, Sheffield, UK,2003)

[11] Karin Bijsterveld, 2003- *Soundscapes of the Urban Past*. (Staged Sound as Mediated Cultural Heritage,2003),12-18

[12] Wei Yang, Jian Kang, *Soundscape and Sound Preferences in Urban Squares*, (School of Architecture, University of Sheffield, Sheffield, UK,2003), 45-51

[13] Karin Bijsterveld,2013-*Soundscape of the Urban Past,25* - „oriunde ne-am afla, ceea ce auzim mai mult sunt zgomote și aceste zgomote ne deranjează atunci când le ignorăm, dar ne fascinează când le ascultăm"

squares, average width, shape coefficient, deformation coefficient, perimeter, perimeter of the enclosure, area of the squares. These shape elements were correlated by the simple and multiple regression method with the behavioral attributes of the space syntax determined by the DepthMapX instrument.

The production of a final sound design tool for squares or their re-walking was a major objective achieved in stages. A first stage consisted of assigning sound values to the axial lines (as an analytical component of the sound maps analyzed through the DepthMapx application), superimposing the sound fields in the analyzed squares over the areas of the visual fields determined through VGA analyses with the same application or over the convex areas of these spaces. The optimal correlations between the visual attributes of the three types of analyses and the average, minimum, maximum sound values assigned to the axial lines or VGA fields or convex spaces were then followed. From these last correlative analyses, spaces with variations between the content, form and sound variations depending on their specific elements, called choremes, resulted. Choremes were chosen as a way of representing the space of the squares and of encoding the sound information transmitted by architectural forms or the organization of the space. Why Choremes? The following answers the question above and argues, exemplifies the use, as an absolute novelty of the work, of choremes in architectural thinking and design. The name choreme comes from the Latin word Choros which means region, space. We have adopted the name and spelling choreme although coreme is also used, getting closer to the French or English[14] original. They are in fact expressive cartographic representations related to space and the energies that give rise to them through their configuration. They are in fact expressive cartographic representations related to space and the energies that give rise to their configuration. Of course, the design and implementation of an open space such as a square or its reambulatory requires a qualitative component that can be conferred by the perception of the designed space by users. For such an approach, perceptual codes are needed. This was a final objective achieved in this research work. The descriptive establishment of these codes and their application on masses of users (defined for what is called in sociological sciences the initial reference mass), a sample that can have between 10-30 members.

[14] „Chorématique” în franceză și „Chorematics” în engleză. Unele lucrări folosesc și termenul de core.

3. Methodology and tools used in doctoral research

The methods used in the development of the doctoral thesis were adapted to the research context and the research stage. A first stage consisted of archiving the morphological elements of the four studied squares of the Museum, Avram Iancu, Unirii and Mihai Viteazu. A set of morphological elements was established that were determined through measurements on Google Earth. For example, for Mihai Viteazu Square, the determined values and their significance are found in figure 3.1. respectively table 3.1.

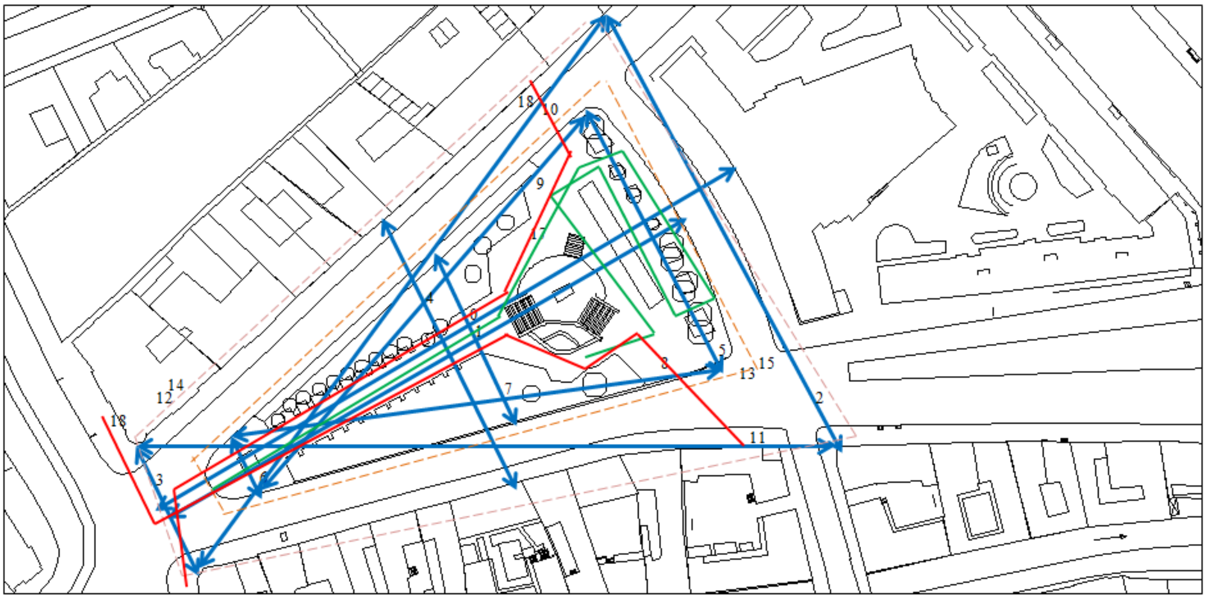


Fig. 3.1. Example of morphological elements of Mihai Viteazu Square determined on Google Earth support associated with table 3.1. (personal creation on OpenStreetView support).

Tab. 3.1. Values of morphological elements determined by measurements on Google Earth, for Mihai Viteazu Square. (personal creation on Google Earth).

PIAȚA MIHAI VITEAZU		
ELEMENTE DE CONFIGURAȚIE	COD	VALORI ALE ELEMNTELOR DE CONFIGURAȚIE
LUNGIME PIAȚĂ FIZICĂ	0	173,62m
LUNGIME PIAȚĂ ACTIVĂ	1	155,73m
LĂȚIME PIAȚĂ 1 FIZICĂ	2	129,35m
LĂȚIME PIAȚĂ 2 FIZICĂ	3	47,18m
MEDIE LĂȚIME FIZICĂ	4	88,265m
LĂȚIME PIAȚĂ 1 ACTIVĂ	5	90,2m
LĂȚIME PIAȚĂ 2 ACTIVĂ	6	13,73m
MEDIE LĂȚIME ACTIVĂ	7	51,965m
LĂȚIME ALEI PIETONALE		Max- 9,53m, Min-4,47m
DIAGONAL 1PIAȚA ACTIVĂ	8	154,69m
DIAGONAL 2 PIAȚĂ ACTIVĂ	9	154,77m
DIAGONALĂ 1 PIAȚĂ FIZICĂ	10	200,3m
DIAGONALĂ 2 PIAȚĂ FIZICĂ	11	204,31m
ARIE PIAȚĂ FIZICĂ	12	14258,89m^2
ARIE PIAȚĂ ACTIVĂ	13	6397,19 m^2
PERIMETRUL PIAȚĂ FIZICĂ	14	553,95m
PERIMETRUL PIAȚĂ ACTIVĂ	15	391,03m
PERIMETRUL STRĂZILOR DE INSERȚIE	16	62,5m
LUNGIMEA TRASEU DE VIZITARE	17	335,16m
LUNGIME TRASEU DE TRANZIT	18	214,43m -188,52m
COEFICIENT DE LUNGIME		0,3381
SUPRAFAȚĂ PIETONALĂ		3184,33m^2
PERIMETRUL PIETONAL EXTERIOR		418,3m
SUPRAFATA TROTUARELOR		3263,49m^2

A successive methodical step consisted in defining the syntax of space and associated with it the realization of a tutorial applicable to the research of the present work of the DepthMapX application.

In fact, the concept of the syntax of space was developed by Prof. Bill Hillier, Dr. Julienne Hanson and colleagues from the Architectural Studies Unit at the Bartlett School of Graduate Studies, University College London. The spatial configuration imposes a morphic language, a language of the arrangement of objects in space, so space becomes a social space with behavioral meanings. The arrangement of objects in urban space, and not only imposes a syntax, a syntax of space. From now on, the role of the architect active in territorial planning is to build a syntax of space „so that syntax is both a theory of the constructivity of spatial order and a theory of how abstract descriptions can be extracted from it: that is, a theory of morphology and at the same time a theory of abstract knowledge."[15]. The tool for this theory is the DepthMapX application.

The main forms of analysis used by DepthMapX, the quantification of which leads to the obtaining of values denoting the features of the analyzed open space, are exemplified below. An important analytical variant is the axial map formed by axial lines. Axial lines are the longest lines of sight in a linear movement that occurs in open space such as streets (also considered convex spaces in the theory of space syntax). These lines intersect along the street, sidewalk or natural street as Turner[16] calls it (the natural street being considered the one with joints of up to 450). The width of the streets, sidewalks is marked by the length of the axial lines. The axial lines are characterized by attributes determined by the DepthMapX application, among which those used in the work are mainly their integration, connectivity and choice. Each of the listed attributes also has urban planning meanings. For example: *Integration* or „proximity" signifies the accessibility of each segment to all others under different types of distance and at different scales, this from the point of view of human behavior indicates the phrase „on the move". Low values of integration indicate a segregated space. *Connectivity* is given by the number of connections of a street with other streets. The *Choice* describes how likely it is to pass through, on the axial line covering a convex space, in trips and therefore, it is the potential as a route, from all segments to all others. For example, for drawing the axial lines in Piața Mihai Viteazu, the manual method can be used and it can be calibrated with the automatic one (Fig.3.2).

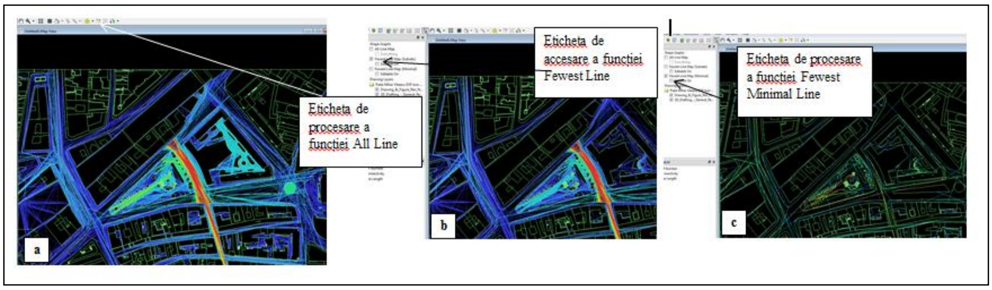


Fig. 3.2. Example of using automatic axial line drawing with the three variants of All Line, Feweast Line and Fewest Minimal Line for Mihai Viteazu Square. (personal creation in DepthMapX).

Simultaneously with the drawing of the axial lines, the application displays the values of the above attributes.

---

[15] ,, Astfel încât sintaxa să fie atât o teorie a constructivității ordinii spațiale, cât și o teorie a modului în care descrierile abstracte pot fi extrase din ea: adică o teorie a morfologiei și, în același timp, o teorie a cunoștinței abstracte." (B. H. Hillier 1984, p. 67)

[16] (A. Turner 2001)

In the same procedural way, the application performs analyses for the VGA convex space variants.
An important method frequently applied in the present research is calibration, triangulation of data obtained in different stages of the work. For the analysis of the axial maps, the calibration was performed by segment type analysis, an analytical variant of the DepthMapX application that reduces the axial lines (with intersections where there are „stumps" of connection) to segments delimited by two intersections of an axial line. In the field, the calibration was performed by the route method.

One of the methods that represents a particularly important novelty of the work is the creation of maps in isophones. Their creation was carried out in several stages.

The first stage consisted of establishing a measurement calendar carried out periodically during a calendar year (2023). The measurements were carried out in the Lday interval. In the measurements of urban sonorities, three time intervals of the day are accepted. These are Lday (07:00–19:00), Levening (19:00–23:00) and Lnight (23:00–07:00), obviously local time. The sum of the measurements from the three time periods is part of Lden.

A first necessity in defining the soundscapes in the studied squares was to create meaningful and interpretable sound maps in order to determine connections between the space of the squares and their loudness. This approach began with the creation of the sound measurement grid (Fig.3.3.). The grid statistically tried to cover the physical space of the squares. In relation to their average surface area (of the squares) and to the sound detail requirements, we created grids with cells with sides between 3 and 10m (approximately). The measurements were made with a UT350 decibel meter with the scale set to the range 30 - 100 dB on type A frequencies (common frequencies in open space). In terms of time, a measurement session for a square lasted about 2-2.5h. This time lag required repeated measurements to achieve the statistical average of the determined values. Such values are called Leq (equivalent continuous sound level). The recordings were made for 3 minutes with the maximum and minimum values of Leq recorded. We used two height levels 1.10m (with effects on static users) and 1.80m (with effects on dynamic users).

A third stage, and the most important one, is the creation of isophone maps. Based on these measurements made according to a calendar of hourly intervals, we created sound maps in isophones. The creation of the isophone maps was done using the Kriging interpolation method. (Fig.3.4.)

Fig.3.3. Construction of the measurement grid on the example of Unirii Square with the numbering of points on the set of the four studied squares. (personal creation on OpenStreetView support).

Fig. 3.4. Isophone map made for maximum values based on measurements from 12.07.2022 from the time interval 10.20-12.13 at 1.10m (personal creation on Google Earth support, accessed on 14.08.2023).

An important methodological step was to determine the mean, minimum and maximum sound values for the manually constructed axial lines (with attributes determined by DepthMapx). This step was achieved by comparing the square-specific axial maps with the isophone maps, following the isophone curves intersected by the axial lines. For the VGA analyses, comparisons were made between the sound fields of the soundscape and the maximum or minimum fields of the attributes of the map variants created by these variants of the DepthMapX application.

An extremely important stage was the filtering of factors influencing sound measurements and comparisons. The main factors highlighted by the thematic bibliography addressed and at the same time noted in the field studies are classifiable from our point of view into operable factors through the skills of an architect, space planner and non-operable factors. The first category includes those listed in previous chapters such as: the dimensions of the spaces, the form elements of the spaces, the shape and dimensions of the architectural objects in the analyzed space, the way they are organized in space, the type of facades that enclose the space, the type of subbase, the opening of the sky, the organization of the road system (if any). All these listed elements communicate with the user, as we said through the morphic language syntactically organized through the syntax of the space. As for the non-operable elements by the architect, they are mainly: microclimate elements, the energetic and informational message of the sound sources (especially road traffic), their frequency (scheduled or not), the type of linear point source of area, volume, the position of the sound sources in relation to the space we call the active space of the square. Through analyses applied to concrete examples, we have demonstrated that these factors have little influence on the soundscape of the analyzed squares and on the sound perception of the spaces of these squares.

In accordance with the above filtering operation, we determined the architectural or organizational factors of open spaces that are important in determining the sonorities of the squares. Extremely important are the grassy surfaces that play a high role in sound absorption (Fig.3.5).

Fig.3.5. For the measurements in Mihai Viteazu Square on 10.09. 2022 carried out using the grid method, a rapid decrease in the SPL values expressed in LAeq (area indicated by the arrow) is observed due to the high absorption of the grassy surface. (personal achievement).

Atmospheric absorption can be determined according to the „openness of the sky" (another factor adjustable by the architect) easily calculated by spherical projection, being the ratio between the surface of the sky and the surface of the projection circle.

The type of surface of the buildings (the degree of loading with decorative elements or the variety of opening elements that determine the roughness of the surfaces) influences the type of reflection and thus the reverberation time. Various studies determine the influence of frequency on the propagation of sound on rough facades. For low frequencies, facades behave like flat ones with specular reflection, at medium and high frequencies the degree of diffusion is accentuated. In the case of the present study, the measured frequencies were the medium ones, they characterize the sounds in a high percentage from a sound space. Balconies also fall into the category of roughness of facades, which through detailed construction can attenuate SPL values with values between 4-8dB. In this case, diffuse waves with rapid dB losses predominate, as well as diffracted waves reaching the free wall of the balcony. [17]

[17] (Eldien H.h. 2005, pg. 2)

An important determined process is *the mask* (physical mask) that interposes between the sound source and the receiver. Such a mask, depending on its dimensions and shapes (imposes the type of waves) can produce areas of sound shadow. (Fig.3.5.)

Fig. 3.5 Sound shadow produced by the Mihai Viteazu statuary complex of about 2 dB having as source the artesian well (S) having a level of 72 dB with a receiver position at the virtual point (R), where 70 dB is felt. The detail is part of the isophone map made on the measurement grid dated 15.08.2022 (personal creation).

Diffracted waves occur when waves come into contact with edges of architectural forms or the subsoil. Diffraction at the edge point can manifest itself through the process of diffusion or through the geometric variant of wave propagation (image source). (Fig.3.6.)

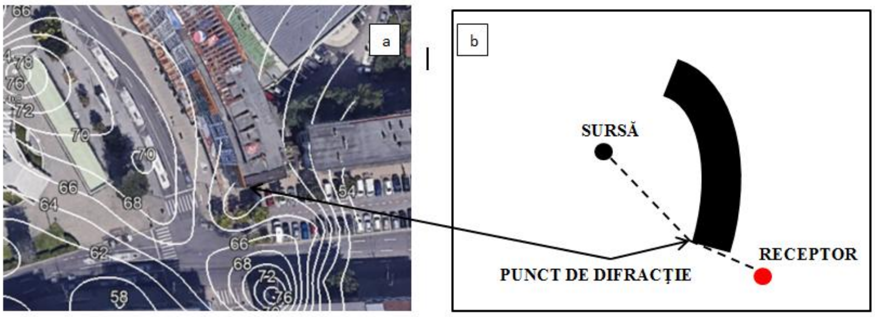


Fig. 3.6. Graphical representation of the diffraction process on the SE corner of the Florin Piersic Cinema in Mihai Viteazu Square using the isophone map developed based on measurements from 29.08.2022 (personal creation).

The roof configuration is also extremely important in the sound diffraction process. a process that can affect facades not exposed to the sound source or, in the case of the present study, for the transmission of sound on streets parallel to the facades of buildings within the boundaries of the squares.

In the case of squares, the losses or inflow of sound determined by the *perimeter of the enclosure* are also important.

An important method in the stage of correlations between the values of the spatial syntax attributes and the sound values assigned to the axial lines or checkered fields in the VGA version is that of the method of simple or complex correlations. In any type of science that allows the quantification of sets of variables dependent or independent of each other, which define a spatial entity or of any type, the correlation technique can be applied. The method consists of determining values that describe the relationship between two or more quantified variables with which one operates in a certain field. Simple regression is also called linear regression because it follows the way of aligning the values of the two variables along a straight line. The important value is R2, which explains in percentage terms how much of the dependent variable is explained by the independent one.

Multiple regression, more complex, establishes relationships between a dependent variable and independent variables using the R value, also called McPearson multiple correlation. R values range from 0 to 1, with high values indicating a high degree of correlation and determination. Simple correlation is also a model for predicting the dependent variable. R2 is the square of the correlation value R. It is used to reduce the prediction errors of R. To determine multiple correlation, also called „multiple regression" or the „least squares" method, several indicators are used that certify the validity of the model of the method.

The use of the two correlative methods is extremely important in research architecture and even more so in territorial planning (architecture of space). It is a particularly important tool among other things by determining the spatial, closed or open architectural elements that are associated with high frequencies of use by users. Works in this regard can be mentioned for closed[18] or open[19]. architectural spaces.

The present work in the correlative analysis uses the complex correlation but predominantly the simple one in comparisons between the attributes of the axial lines and their sound values as well as for the values of the sound fields and the fields of visibility. The comparisons were carried out as a novelty in the field of organizing open spaces from a visual and sound point of view. The premiere character requires even in the summary version of the short thesis details. The correlative analysis was carried out comparatively on isophone maps made following measurements from different dates. The sectorization of the squares by features specific to their *center* and *edge* imposed, in the case of the analysis of the axial lines and not only, comparisons for each square between the correlations between the attributes of the spatial syntax and the average sound values that belong to each axial line on these sectors. Comparisons were made for axial lines *with sound values below* and *above* the average sound of the square soundscape on the measurement date. To determine the involvement of spatial syntax attribute values in sound correlations for each attribute, choice, integration, connectivity, two classes were created depending on the average value of these attributes. Comparisons were made for the integrated axial lines of high-choice routes that have the potential to be used for tourist purposes (*tourist routes*).

One of the absolute novelties of the work is the use of an extremely expressive cartographic support that combines the morphological features of some sectors in the analyzed square space, which determines a type of sound message for the dynamic or static user of those spaces.

Architectural sciences use Lynch's perceptual models to describe open spaces. Lynch's model[20] refers to large-scale urban spaces and was born from empiricism applied to a variable set of respondents (between 15 and 30 people) in seven major U.S. cities. The study was based on the analysis of central areas of approximately 4x2.4 km in American localities in two stages. The first stage determined the objects that compose the image of the surface, the strength of the elements that compose the area, their visibility. In the second stage, the respondents were used through what are called mental maps. The mental maps applied were typical for psycho-cognitive sciences, „mental map", „cognitive map" and „concept map". For the analysis adopted in this paper, the cognitive cartographies of the studied spaces are important after the mass of neutral observers made sketches, imaginary journeys, descriptions, etc. From these experiments, five elements were born that can compose the image, the model of the spatial ensemble at any scale approached. These are routes, limits, sectors, nodes and landmarks.

Choremes were chosen as a way of representing the space of squares and of encoding the sound information transmitted by architectural forms or the organization of space. Choremes are models of physical space with socio-economic and behavioral charge. The correct application of the chorematic modeling method requires a good understanding of the space, a correct deciphering of the visual language which has as attributes antagonistic meanings of asymmetry-symmetry, fragmentation-unity, accent-neutrality, etc. The operator

[18] (Ballas 1993, 8), (Petros 2019, 18)
[19] (Brambilla G. 2008, 12)
[20] (K. Lynch 2012) în traducerea lui Alexandru-Ionuţ Petrişor

must use a realistic, abstract and symbolic vision. The defining elements of the chorematic model are:

• *Structure* refers to the way in which space is divided into homogeneous units at least according to one variable. In our case, it can be applied to spaces in which we have determined axial lines with a determining role in involving the correlations of their attributes with the average sound values.

• *Layout* is the circulation infrastructure of energy flows. References can be to road and pedestrian transport. In our case, it is about circulation axes and VGA fields superimposed with sound fields.

• *Gravity* refers to the element of space through the direction of attraction center and periphery. In our case, for the physical support, the objects that can constitute poles of attraction and in the sound sense are the dominant sounds with a comfortable sound source, in this case we are talking about attractive poles or unpleasant sound source, therefore a repulsive sound source.

• *Contact* is the interface between two different organizational states. The horizontal reading of figure 27 indicates the possibility of the existence of „bridgehead" variants, contact area, etc. In the case of squares, a situation from the tabular ones of the contact variants would be the alignment of the terraces on the western side of Unirii Square as a model of the configuration and as a superimposed sound model would be the bridgehead for the sonorities emitted by the ambient music of the terraces.

• *Tropisms* are an expression of orientations on different dominant directions, directional or gradient dissymmetries of energies.

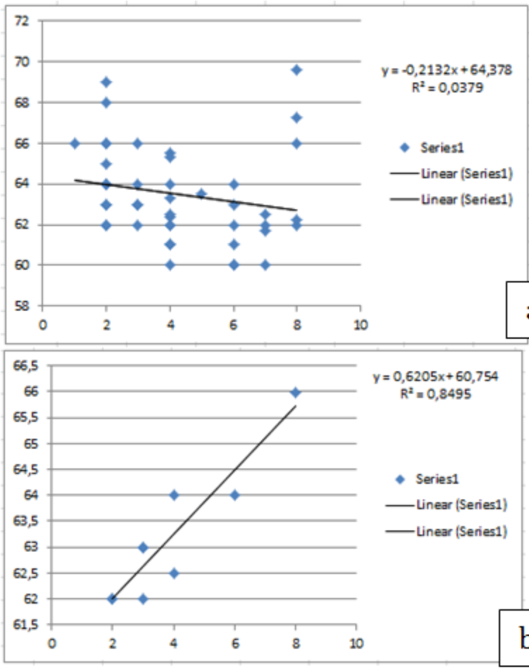
• *Territorial dynamics* represent withdrawals or expansions of areas well exemplified by the closed surfaces of isophones constructed at different hourly intervals or between the measured maxima and minima.

• *Hierarchies* represent the last line of Brunet's proposals. The examples in this case can be found in the continuation of the work, we only mention that such hierarchies are important both in terms of spatial and sound configuration in the design and organization of open spaces.

Graphic modeling can be applied at any scale and is applicable to any process that is related to space. It is thus certain that this type of modeling is applicable to the researched sound theme. The development of such models was carried out in several stages that require details that we will summarize below. The emphasis was placed on the type of correlations between the attributes of the axial lines specific to axial maps as an analytical variant of open spaces for the dynamic user and the average sound values identified for each axial line. The stages of creating the choremas found in the work were the following:

• a first step in the case of each square was to determine the correlations between the average sound values of the axial lines and their attributes of integration, connectivity, choice as attributes of the space syntax that indicate possible behaviors of dynamic users (in the case of axial maps). In most cases the correlations on the complete sets of axial lines were of low values. From this point on, we used as an immediate next step the selection of axial lines in such a way as to raise the value of the correlation.

• The distribution of points on the graph denotes the existence of correlation only between certain points. In this situation, we eliminated points from each graph successively until the values of R2 increased. We thus determined sectoral correlations between the value of connectivity, integration or choice and the sound values assigned to the axial lines. In the present case (and in general we determined two sets of values with good correlations that we propagated on all the measurements performed V1, V2, to which we added values specific to the dual measurement V3, V4). For the correlative variants V1, V2, V3, V4 we determined correlations that encompass the entire range of values, (short) correlations that encompass only a segment of the range of values or inverse correlations (negative correlations). Of course we also followed the use of sets of sector lines, we rarely accepted dispersed sectors for analytical ease. (Fig. 3.7.)



CORELAȚIA DINTRE CONECTIVITATEA CELOR 65 DE LINII AXIALE CE COMPUN HARTA AXIALĂ PENTRU PIAȚA AVRAM IANCU ȘI VALORILE LOR MEDII SONORE

LINII AXIALE V1	CONECTIVITATE OPTIM	VALOARE MEDIE SONORĂ 18.08
14	8	66
21	3	62
22	3	63
28	3	63
33	4	62,5
34	2	62
38	2	62
48	6	64
50	4	64

Fig. 3.7. Example of the implementation of variants V1, V2, V3, V4, by eliminating axial lines to optimize the correlation values between the connectivity of axial lines and their average sound values on the example of Avram Iancu square using the maps with isolines from the dates of 18.08 and 27.10.2022 (personal implementation on Excel 2010).

• for each square, between 6 and 8 pairs of comparisons were made in which the variants V1, V2 were used, for each type of comparison mentioned above. The variants V3, V4 were specific to each comparison. In these variants, we followed with predilection the lines involved predominantly in each of the variants used in all types of comparisons (*center - edge, sound values below - above the average sound of the landscape, tourist routes or connectivity classes, integration choice - average sound values*)

• the predominant lines mentioned were determined through synthesis analyses for all the data analyzed in a square. They were called choremic lines, having the property of modifying the correlative level of the spaces in which they are found at the level of all types of comparisons. (Tab. 3.2.).

Tab.3.2. Lines involved in high-level correlations between the sound values of the axial lines and their integration values on the example of Mihai Viteazu square (personal achievement).

LINII AXIALE	2	4	5	9	10	11	12	13	14	15	19	20	21
V1													
V2													
V3													
V4													

• these choremic lines were correlated with the shape elements of the sectors where they are found, creating types of choremic spaces indicating direct or inverse types of correlation (inverse correlation denoting the increase in sonorities with the decrease in the values of the analyzed attribute). (Fig. 3.8.)

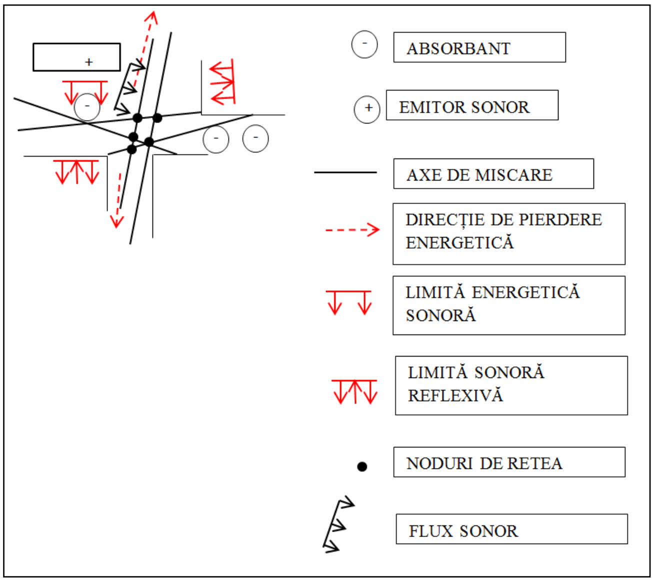


Fig. 3.8. Chorema 1 din piața Muzeului (realizare pesonală).

A new important step after the creation of the choremic spaces was to achieve the concordance between the attributes determined by the DepthMapX application related to the internal organization of the squares and the values of the sound fields correlated with these attributes. These are the compactness of the convex space (how close the space is to the shape of a disk), the first moment of inertia attribute (which expresses the degree of elongation of the convex space), visual control and visual controllability, isovist area, isovist perimeter. These attributes serve to analyze the spaces in the squares related to the static user. For example, for Avram Iancu Square, the values of these attributes correlated with the size of the sound fields can be seen in figure 3.9.

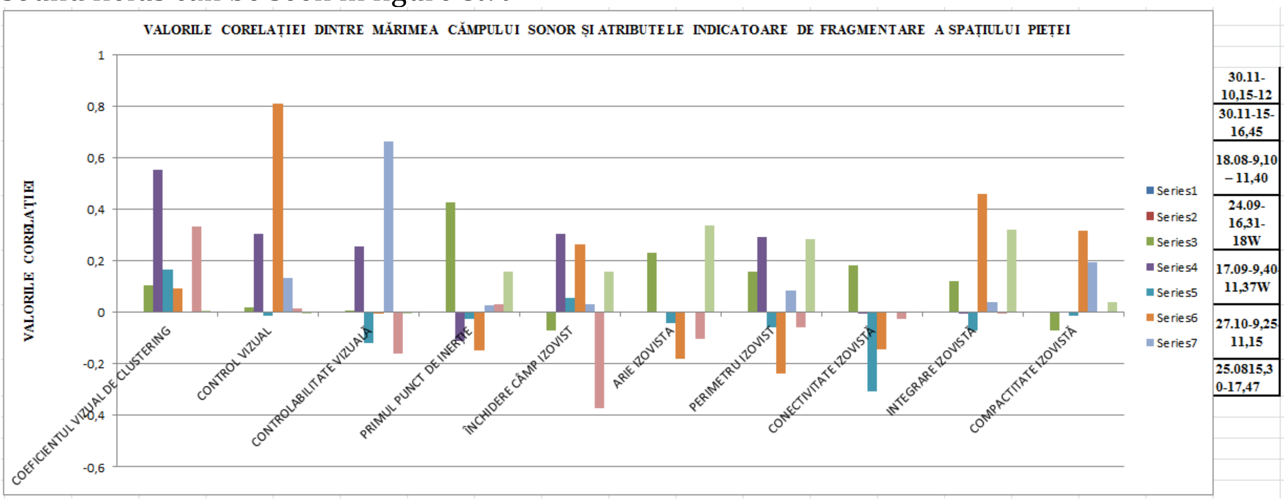


Fig. 3.9. Correlative example between the attributes mentioned in the figure that determine the quality of the internal organization of the Avram Iancu square and the size of the sound field. The colors signify the analysis data mentioned in the right column (personal creation on Excel 2010 support).

The questionnaire method was applied to audio-video recordings in each of the choremic spaces in the chapter dedicated to the choremic analysis in the four squares. In the central points of the choremic spaces, these recordings were made in the perspective version at 3600 in different campaigns in each month of 2023. They were made in the morning and afternoon hours. The recordings were made with the SPLCam application, an application that

records the graph of the variation of acoustic intensity in average, maximum, and minimum values.
A final stage in the line of research methods consisted of coding the perception of the choremic spaces by this sample that analyzed the sound-visual simulation of the recordings from the choremic spaces. Perception is apparently relative. In order to acquire scientific value, there must be quantifiable perception keys that can then be coded. In the scientific world, there is a wide variety of such perceptual evaluation keys.

Codified, standardized perception can become a basic tool for the architect or urban planner. „The emphasis on perception and interpretation is fundamental to soundscape research”[21]. Axelsson adds, mentioning as perceptual landmarks of sound spaces pleasure, event (in the sense of excitement produced by a public environment with many events), familiarity expressed on a Likert scale. Archiving questionnaires on these perceptual landmarks can create additional fields of perception of sound language, implicitly as we have established of morphic language. It is about the chaotic, monotonous, calm, exciting perceptual field. These spatially represented, coded perceptual fields can be superimposed on the analysis elements of the visual instrument DepthMapX. They can be applied to analyze the soundscape of squares, on the dominant sounds in squares, on aspects of the morphology of the square space with a sound role, etc. Through such approaches, proportions of involvement in the perception of the square space between visual and sound can be quantified. The present work used the coding variant in figure 3.10.

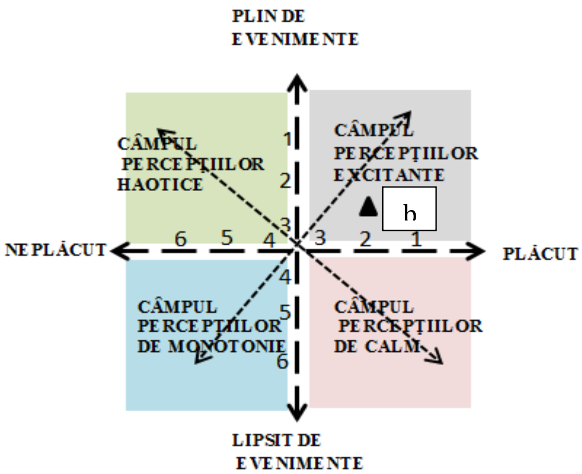


Fig.3.10. Example of application of the perceptual graph for the pleasant-unpleasant axes, with events-lack of events that give rise to the perceptions of chaotic, calm, monotonous, exciting, (a) the exemplification model, (b) the example applied to a sample of 20 subjects (personal realization).

For Avram Iancu Square, the coding is shown in figure 3.11.

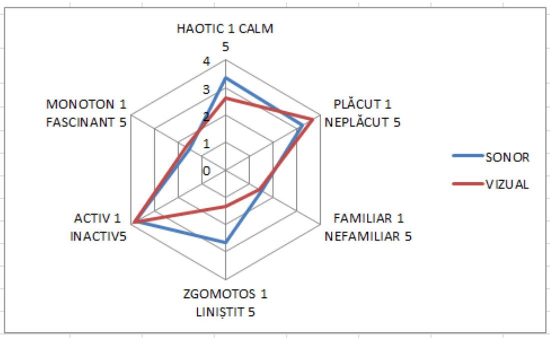


Fig. 3.11 Evaluation of the sound perception of space and modification by adding visuals for the chorema in Avram Iancu Square (personal achievement).

[21] „Accentul pus pe percepție și interpretare este fundamental pentru cercetarea peisajului sonor” Truax, 2001citat de (Axelsson O. 2010, pg. 2836)

The coding method presented above was calibrated by the agent method, a variant of the DepthMapX application. The agent method is a variant of the DepthMapX application through which the movement of agents with settable behavior on the tourist variant in a space of any type is modeled. For the present work, we obviously used the spaces of the researched squares. The movement of agents is done by searching for a visual optimum. In the present work, we used three groups of 10 physical participants in such modeling on the agent model. One group was neutral in terms of visual and sound perception qualities, one of the groups had a special sound acuity (conservatory students) and the third (group of architecture students) with a visual acuity.

The modeling within the DepthMapX application was performed with the possibility for each agent to perform 1000 steps in the system with a change of direction every 3 steps, the movement is done along the length of the view. In this situation, the paths recorded in search of the visible optimum are identical to the paths marked by the participants with visual acuity. The participants in the modeling neutral as to the visual perceptual quality and those with the special auditory perceptual quality stayed in the sector with the auditory optimum in the areas of the two choremic areas marked with red circles in Figure 3.12 (for the example of the Museum square). The three groups were instructed to search for the visual (high visual acuity group) and auditory (neutral and high auditory acuity groups) optimum.

Fig. 3.12. Trasele înregistrate (cu aplicația trackmarker) a participanților la modelarea fizică de către grupul cu percepții sonore deosebite (a) neutrii ca și calități perceptuale (b) și grupul cu calități perceptuale vizuale ce au calibrat trasele aplicației (c)(realizare personală).

It should be added that during the modeling the participants were asked to argue the choice of the optimal sound. Among the arguments we mention quoting: „People's conversations and birds chirping could be heard in the background. It is a perfect place where you can relax in a square, forgetting the noise of some crowded places in the city" or for the visual in the same choremic space for which we built the graphic representation: „From a visual point of view I considered that this is the most pleasant place it offers a pleasant light, provided by the lights of the terraces, also the trees cast a magnificent play of shadows. Finally the monument placed between the trees highlights the beauty of the square"

4. Discussions

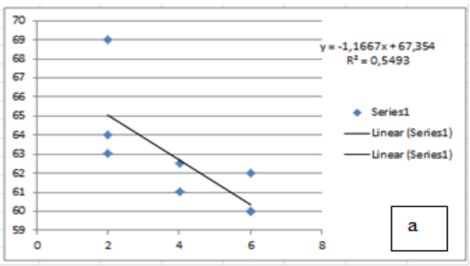
The declared goal of the doctoral thesis, the summary of which is this text, was, in summary, to demonstrate connections between the form elements of open urban perimeters such as squares and those of the spatial configuration attributes on the principles of space syntax, to demonstrate legible connections between the attributes of spatial syntax and the soundscape of squares, to find solutions to produce a tool for sound and visual re-walking of squares and to find methods that are easily manageable by the architect operator in the process of designing an open space such as squares, from a sound and visual point of view.

As for the first of the goals listed above, to demonstrate connections between the form elements and the spatial configuration of squares through analyses in the axial map and VGA variants is not new in the field. The method has been addressed in numerous sets of research such as doctoral theses, articles, conferences. The methodological novelty is brought by the calibration mode of the values determined by the mentioned variants of the DepthMapX application. The calibration was carried out by route-type measurements as well as by control attributes of the application (segment analysis, convex space analysis or application of axial lines on the automatic module). Of course, the final goal of this stage was to determine the mentioned correlation between the morphological elements of the analyzed squares and their spatial configuration. In this sense, we applied simple and complex correlations to the model and other works in the displayed bibliography. Compared to the numerous other works that used such methods, we created correlation matrices using what we called the shape elements of the active and physical spaces of the squares. These matrices can constitute true visual design tools for the squares. Unfortunately, in their implementation, the risk of errors is higher than in other studies because the correlated set contained only four squares (the set of independent values).

The second outlined goal, in fact the most important one, was to demonstrate connections between the spatial configuration of the squares and their perceived sonorities. This goal was fully achieved either through the correlative variants mentioned in the case of the analysis through axial maps, or through the VGA analysis for the internal organization of the squares. Reambulation and the way of achieving it from a sound and visual point of view is an absolute novelty in the specialized literature. for example, a correlative analysis between the average sound values given to the axial lines and the connectivity of these lines (as an attribute of the spatial configuration) is used.

LINII AXIALE	CONECTIVITATE TRASEU 1	VALOARE MEDIE SONORĂ 18.08
5	2	69
18	4	61
23	6	60
24	6	60
30	6	62
33	4	62,5
35	2	64
37	2	63

LINII AXIALE	CONECTIVITATE TRASEU 1	VALOARE MEDIE SONORĂ 18.08
5	2	69
18	4	65
23	6	60
24	2	67
30	6	62
33	4	62,5
35	2	64



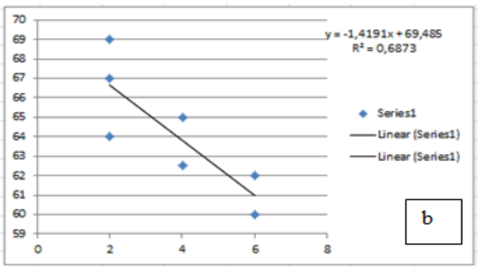


Fig. 4.1 Procedural example of modifying the sonorities of a sector in Avram Iancu Square by modifying the connectivity of axial lines (personal creation on Excel).

For figure 7.4.2.8. if at the initial state (a) of the organization of space we intervene by decreasing the connectivity of axial line 24 from 6 to 2 we increase the loudness to 67 dB, at access line 18 we increase the loudness from 61 dB to 65 dB and we eliminate the access of line 37 we reach a correlation of 0.6873 (b).For figure 180 if at the initial state (a) of the organization of space we intervene by decreasing the connectivity of axial line 24 from 6 to 2 we increase the loudness to 67 dB, at access line 18 we increase the loudness from 61 dB to 65 dB and we eliminate the access of line 37 we reach a correlation of 0.6873 (b).

As a method for designing open spaces, we have opened doors to its improvement by implementing the methodical line of realization, which represents an absolute novelty of the present work. In order to become operable, the method requires a long-term collective activity in terms of producing sets of choremes encoded through perceptions.

5. Conclusions

Of course, the conclusions must refer to the achievement of the goals proposed at such a specific beginning of a thematic research work of such a scope. A first goal was to demonstrate legible connections between the operable form elements for the planning architect and the attributes of the syntax of space that define attitudes, human behaviors depending on the organization of squares. The matrix diagrams developed clearly prove the connections of the form elements and these attributes. Through these matrices, we created intervention models on the organization of open spaces such as squares. Specifically, by using such matrices by operating on the form elements, the attributes of the syntax of space, more precisely human behavior, can be influenced. For the interior organization elements, the matrices equally represent a tool for positioning objects according to dimensions and socio-cultural functions to ensure visual and sound attractiveness. Such matrices based on visual perception are a premiere in the sciences of territorial planning in Romania, with the use of the DepthMapX application.

Another important goal was to demonstrate connectivity between the organization, configuration of open spaces such as squares and sound sectors determined by configurational typologies. The paper demonstrates such connectivity between sound energies and the organization of spaces, sectors of squares. The thesis demonstrates these well-determined connections depending on the organizational elements, green spaces, arboreal vegetation, the dimensions and shape of pedestrian paths in relation to the shape and dimensions of the content objects of the squares.

Such a dependency to create typologies applicable in the organization of open spaces requires standardized energy spaces. The thesis for the first time constructs such choremic spaces demonstrating the usefulness of such a method in the design and re-ambulatory of urban squares. It is true that sets of such types of choremic spaces are needed that require an organized and long-term activity. However, the present paper opens doors to such an approach.

The detailed analysis on the model of the studied squares demonstrates the usefulness of axial and VGA maps as variants of analysis of certain types of squares. The correlations demonstrated by the work between the attributes of the axial lines and their sound values demonstrate the role of such an analysis in the re-ambulatory of certain squares by intervening on the attributes of the axial lines or VGAs by varying these attributes (operable by the architect).

We wanted to succeed in transforming the DepthMapX application into a useful tool for the planning architect by doubling the visual and sound analysis function. The correlation relationships demonstrated between visual and sound allow this. Of course, algorithmic details are needed, but through this work we have opened the way to such facilities. The association of the DepthMapX tool and sound valences also represents an opening towards such analyses through the novelty of the present approach. In terms of the originality of the instruments used in this research, it is worth mentioning the type of construction of the isophone maps starting from the planning of the activity (measurement grid, making isophone maps, assigning sound values to the square spaces). The application of complex or simple regression in correlative analyses between sound values and space syntax attributes is also a Romanian novelty, the method being applied in several studies in international works. The efficiency of the method was triangulated by other methods listed in the work (the method of tasees, car frequency).

It is important to remember the efficiency of the sound measurement method. The chosen method does not correspond to international sound determination norms (measurement height, distance from objects), but it is confirmed by the way in which the sound space is perceived by users in terms of sound comfort or discomfort. Also in the chapter on measurement instruments and the correctness of their use, we mention the type of perceptual evaluation of the soundscape. A much debated topic in architectural works is the form of evaluation that indicates the correct perception of open spaces. According to the present work, we can state that the use of psycho-social benchmarks established by several sociological works in collaboration with architects is correct, managing to dissociate the perception of visual spaces from the sound one, the dominance of one or the other of the perceptions depending on the spatial configuration. The present work identifies dominant sound or visual spaces and therefore implicitly their structure in order to achieve a type of sound or visual comfort or both simultaneously.

We wanted to code the types of choremes according to the psycho-cognitive parameters of perception. For the deciphered choremes we managed to demonstrate the existence of sound coding methods. From this point of view, using previously defined perceptual qualities for spaces from a visual and sound point of view, we gave perceptual value to individualized choremes. Coding is a finality of the work that deciphers the way of perception of some spaces and they become equally tools for planning open spaces, being indicators of some choreme spaces that represent, as I said, a cartographic ensemble with sound energies determined by spatial landmarks.

Also important in the instrumental chapter is the role of the axial map and the sonorities applied to the axial lines which, as we have demonstrated in several examples, become instruments for re-arranging open spaces in the direction of producing visually and sonorously comfortable spaces. For example, if we want to create spaces of "quiet" that require comfortable sonorities and attractive views, in this case the procedure determined by the work is:

• construction of an axial map on dxf support.
• sound measurements at two heights 1.10 and 1.80 respectively on a correct statistical grid.
• construction of an isophone map accessible to any architect planning open spaces.
• assignment of sound values to axial lines (movement lines of dynamic users), by comparing axial maps with the isophone one.
• achievement of correlation between space syntax attributes and their sonorities.
• type of negative or positive correlation indicates the type of variation of sonorities depending on the variation of spatial syntax attributes.
• elimination of axial lines to achieve a negative correlation indicating a decrease in sonorities in the case of an increase in the values of the space syntax attributes. The operation will be done on the correlative graph.
• the elimination or variation of the values of the spatial syntax attributes can be done through the internal organization of the spaces or sectors in the squares.
• if we want to arrange commercial spaces with an animated sonority, we will choose the positive correlation variant by which varying an attribute of the axial lines increases the sonority.

If we want to design an open space like a square, the applicability of the present thesis is demonstrated in the following way:

• using the matrix in annexes 32,33, the form elements that are correlated with landmarks of the space syntax attributes are chosen. For example, following Annex 32 (if the square also has road routes), we choose the deformation coefficient as an important benchmark because it (red squares) influences the integration of the axial lines and their length, therefore implicitly the directions and length of the directions of movement, and from the isovist field it influences the isovist area (the visual field of static users)

• this choice will influence the deformation coefficient of the active space of the square.
• according to the same matrix, this coefficient will strongly influence the internal organization attributes of the active spaces, including visual clustering and point first moment.
• practically, a certain internal organization is required with objects that delimit distinct and clear movement paths (even long ones).
• on such a space with these characteristics, choremic spaces adaptable to its shape and dimensions are then built.
• choremic spaces typified by sets will produce determined sonorities.
• these can be subjected to simulation procedures to determine the codes produced.

An important result of the thesis applicable to the design of open spaces is the filtering of factors that influence the sonority of squares. The paper demonstrated that the internal organization of spaces is a primary determining factor, but we mentioned several problems related to the energetic and informational message of sound sources. In this sense, the existence of sound sources related to automobile transport, we demonstrated that they can be regulated by organizing the spaces or by the intervention of complementary sources that cover the sound produced by road traffic through different frequencies.

This paper opens doors to research on this extremely important topic for the sound organization of open spaces. Of course, compared to what we initially proposed, there are several problems that need to be studied in more depth. This is primarily about how a DepthMapX analysis can be applied to the sonority of spaces. In this sense, a method of cartographic analysis recognizable by the aforementioned application must be identified, with the characteristics of choremic spaces in which the relationship between types of spaces and their sonority should be based on clear algorithms that allow the application to explain the attributes of the syntax of the sound space in correlation with the visual attributes. There is certainly a need for sound mappings of complex urban spaces more than the current ones related to road, rail, and air transport.

We believe that research in the field must be continued at an academic, organized level because it involves endurance activity carried out in a collective manner but of great relevance.

6. REFERENCES

BOOKS

All_Sayed, K., Turner, A., Hillier, B., Iida, S., Penn, A. *Space Syntax Metodology.* UCL London: School of Architecture, 2014.

Axelrod, R. he Complexity of Cooperation: *Agent-Based Models of Competition and Collaboration: Agent-Based Models of Competition and Collaboration*. New Jersey: Princeton university press,, 1997 a.

Bentley, I., Alcock, A., Murrain, P., McGlynn, S. and Smith, G. Responsive Environments: *A Manual for Designers*. London: Architectural Press, 1885.

Bertin, J., *Semiologie graphique*. Paris: EHESS, 2005.

Blesser B., Salter L. R. *Spaces Speak, Are You Listening?* London: MIT Press, 2006.

Brunet, R., *Le dechiffrement du monde.* Paris: Belin, 2001.

Cheng, Wilson Chua Wei. *Analytics for Urban Networks:Integrating Graph Neural Networks with Space Syntax.* London: Imperial College London, Department of Computing, 2022.

Francis, M., *Urban Open Spaces- Designing for User Needs.* London: Island Press, 2003.

Gibson, J., J., *The senses considered as perceptual systems.* Westport, Connecticut: Greenwood Press, 1983.

Hällgren, N., *Designing with Urban Sound - Exploring methods for qualitative sound analysis of the built environment.* Stockholm: TRITA-ABE-DLT-1843, 2019.

Hao, Y.,. *Effects of Urban Morphology on Urban Sound Environment from.* Sheffield: School of Architecture The University of Sheffield, 2014.

Hilier, B., *Space is the machine. Aconfigurational theory of architecture.* London: Space Syntax 4 Huguenot Place, Heneage Street, London E1 5LN, 2007.

Hillier, B., Hanson, J. *The Social logic of Space.* London: CAMBRIDGE UNIVERSITY PRESS, 1984.

Hillier, B., Iida, S. *The human's shortest path is angular not metric.*in preparation, 2004.

JACOBSSON, K., *Urban Grassroots Movements in Central and Eastern Europe.* Dorchester: ASHGATE, 2015.

Kang J., Schulte-Fortkamp B. *Soundscape and the Built Environment.* London: CRC Press, Taylor & Francis Group, 2016.

Kang, J., *Urban Sound Environment .* London: Taylor Francis,, 2007.

Kansky, K., J., *Structure of Transportation Networks: Relationships Between Network Geometry and Regional Characteristics.* Chicago: AddBook, 1963.

Kaplan, K., and Kaplan, R.,. *The Experience of Nature: A Psychological Perspective.* New York: Cambridge University Press, 1989.

Lynch, K. *Managing the Sense of a Region.* Cambridge: MIT Press, 1976

Lynch, Kevin. *Imaginea oraşului.* Bucureşti: Registrul Urbaniştilor din România, 2012.

MASSEY, D. *Pelo espaço.* Rio de Janeiro: Bertrand Brasil, 2008.

Passini, R., and Paul A., *Wayfinding: People, Signs, and Architecture.* New York: McGraw-Hill Book Company, 1992.

Peuquet, D. J. *Representations of Space and Time.* New York: The Guilford Press, 2002.

Raimbault, M. *Simulation des ambiances sonores urbaines: integration des aspects qualitatifs.* Nantes: PhD Thesis, Université de Nantes, 2002.

Shipman T.J., Wilson J.D., Higgins A.C. Juniior. *An Introduction to Physical Science.* London: Brooks/Cole, 2019.

Zumthor, P. *Thinking Architecture.* Berlin: Birkhäuser, 2010.

MAGAZINE ARTICLES

Alaves, S., Laura Estévez-Mauriz, Francesco Aletta, Gemma M. Echevarria-Sanchez, and Virginia Puyana Romero. „*Towards the integration of urban sound planning in urban development processes: the study of four test sites within the SONORUS project."* Noise Mapp, 2015: 2:57–85.

Amphoux, Pascal. „Sound signatures, Configurations and Effects." Arch. & Comport. I Arch. & Behav, 1993: Vol. 9, no. 3, p. 387 - 395.

Auinger, S., and B Odland B., „Reflections on the Sonic Commons." Leonardo Music Journal, Vol. 19, 2009: 63–68.

Axelsson O., Nilsson M. E. „A principal components model of soundscape perception." The Journal of the Acoustical Society of America, 2010: Vol. 128, No. 5, 2836–2846.

Radicchi,R. Pınar Cevikayak, P., Chung, A., , Sharon Stewart,J.P., Tsaligopoulos, A.,Lindsay McCunn & Marcus Grant. *„Sound and the healthy city." Cities & Health*, 2021: 5:1-2, 1-13.

Ballas, J.A. *„Common Factors in the Identification of an Assortment of Brief Everyday Sounds*." Journal of .Experimental Psychology:, 1993: vol 19, nr. 2 , 250-267.

Batty, Michael & Jiang, Bin & Thurstain-Goodwin, Mark. *„Local movement: agent-based models of pedestrian flows."* Working paper. CASA Working Papers (4), 1998: 11-15.

Batty, N., Sanjay, R. *„Reformulating Space Syntax: The Automatic Definition and*." Centre for Advanced Spatial Analysis, Working Paper Series, 2002: 1-40.

Bayram, Ebu. *„Architecture through cognitive mapping, capturing and defining the experienced atmosphere.*" Heritage and Architecture Graduation Studio – 'Adapting 20C Heritage, 2012: 23-31.

Brambilla G., Maffei L., Di Gabriele M. „*Can urban squares be recognized by means of their Soundscape?"* Acoustics 08 Paris. paris: ttps://www.researchgate.net/publication/5326654, 2008. 3265-3268.

Brunet, R., „*Les Composition des modeles dans l'analyse spatiale.*" L'Espace Geographique, nr. 4, 1980: 253-265.

Campos, M. B. de Arruda. „*Strategic spaces:Patterns of Use in Public Squares of the City of London.*" S P A C E SY N T A X FI R S T I N T E R N A T I O N A L SY M P O S I U M, 1997: 26.2-26.11/Vol II.

Cutini, V., „*Smart city, planning for energy, transportation and sustainability of the urban system.*" TeMA, Journal of Land Use, Mobility and Environment, 2014: 97-108.

Cutini, V.,. „*Spatial analysis of urban." T*eMA, Journal of Land Use, Mobility and Environment, 2014: 221-230.

Dyrssen, C. „*City rhythms:space and time."* Byggnadshistoris tidskrift, nr. 57, 2007: 59-72.

Efstathios M., Kang,j., Francesco A. & .Axelsson O., „*On the relationship between land use and sound."* Journal of Urban Design VOL. 25, NO. 5,, 2020: 629–645.

Eldien H.h., Woloszyn P. „*The acoustical influence of balcony depth and parapet form: Experiments and simulations."* Applied Acoustics, 2005: 1-20.

Fritz J.B., Elhilali m., David S. V. Shamma S. A. „*Auditory attention —focusing the searchlight on sound."* ScienceDirect, Current Opinion in Neurobiology, 2007: 17:437–455.

Guillaume G., Dutilleux G., Picaut J. „*Use of the Transmission Line Matrix method for the sound propagation modelling in urban area."* The Journal of the Acoustical Society of America, 2008: 6539-6544.

Helbing, D., and Molnar.P., „*Social force Model for pedestrian Dynamics."* PHYSICALL REVIEW E, 1995: 2127.

Hillier, B. „*Mansion House Square Inquiry - Proof of Evidence."* Unit for Architectural Studies, 1984: 45.

Hillier, B. „*Natural Movement: Or Configuration and Attraction in Urban Pedestrian."* Environment and Planning B, 1993: 20(1):29-66.

Hillier, B., „*The art of placeand the science of space."* World Architecture 11/2005 185 (World), 2005: pp96-102.

Hillier,B., & all. „*Syntactic analysis of settlements."* Architecture et Comportement/Architecture and Behaviour 3, 1987: 217-231.

Hölscher, C., Brösamle, M., & Vrachliotis, G. „*Challenges in Multilevel Wayfinding: A Case Study with the Space Syntax Technique."* Environment and Planning B: Planning and Design, 39(1), 2012: 63–82.https://www.britannica.com/science/memory-psychology. n.d.

Janczur R., Walerian E., Czechowicz M. *„Façade Shaping as Local Means Protecting Against Traffic Noise." ACTA ACUSTICA UNITED WITH ACUSTICA*, 2011: Vol. 97 , 769 – 778.

Jeon, Jin Yong, Jo, Hyun In. *„Evaluation of soundscape and audio–visual factors in VR environment for quiet urban park." Inter.noise 2019, Noise control for a better environment.* Madrid: Noise control for a better environment, 2019. 1-9.

Kang,J., *„Urban sound planning – A soundscape approach."* Acoustics 2019, 2019: 1-6.

Josep Llorca-Bofí, Christian D., Jonas H., and Michael V., *„Urban Sound Auralization and Visualization Framework—Case Study at IHTApark."* Sustainability 14,, 2022: 1-18.

Martinuci, Oséias da Silva. „Geography, graphical semiology and corematic." Mercator, www.mercator.ufc.br, 2016: v. 15, n. 3, p.37-52,.

Menzel, D. Fastl, H., Graf, R. and Hellbrück, J. *„Influence of vehicle color on."* Journal of the Acoustical Society of America, 2008: Vol. 123 (5), pp. 2477-9.

NIA, Mustafa Aziz Amen și Hourakhsh Ahmad. *„The Effect of Cognitive Semiotics on The Interpretation of Urban Space." 4th International Conference of Contemporary Affairs in Architecture and Urbanism.* Alanya: 10.38027/ICCAUA2021227N9, 2021. 260-274.

Nielbo, F., D. Steele, and Guastavino.C., *„Investigating Soundscape Affordances through." Proceedings of Meetings on Acoustics ICA2013*, 2013: 28-32.

Ouzounian, G., *„Sound installation art: from spatial poetics poetics to politics, aesthetics to ethics."* In Music, Sound, and Space: Transformations of Public and Private Experience., 2015: 73–89.

Penn, A., Turner, A., *„Space Syntax Based Agent Simulation."* Springer-Verlag (Schreckenberg, Michael and Sharma, Som Deo,), 2001: pp. 99-114.

Pheasant R., G.R Watts G.R., Horoshenkov v., Barrett B.T. *„The acoustic and visual factors influencing the construction of tranquil space in urban and rural environments tranquil spaces-quiet places?" The Journal of the Acoustical Society of America, 2008: 1446-1458.*

Picaut J., et all. *„Effects of diffuse reflection by building façades on the sound propagation and soundscapes in urban areas."* Euronoise 2006. Tampere: https://www.researchgate.net/publication/266384665, 2006. 1-6.

Pheasant.R.,, Kirill Horoshenkov,K., and Watts.G., *„The acoustic and visual factors influencing the construction of tranquil space in urban and rural environments tranquil spaces-quiet places?"* The Journal of the Acoustical Society of America, 2008: 1446–1457.

Renterghem van T., Botteldooren D. *„Numerical Simulation of the Effect of Trees on Downwind Noise Barrier Performance."* ACTA ACUSTICA UNITED WITH ACUSTICA, 2003: Vol. 89, 764 – 778.

Renterghem van T., Botteldooren D., *„The importance of roof shape for road traffic noise shielding in the urban environment." Journal of Soundand Vibration 329 (2010)*, 2009: 1422–1434.

Romanowska, M. „*Urban Soundscape Preferences in Relation to the Function of a Place: Case Studies in Warsaw." Miscellanea Geographica - Regional Studies on Development*, 2018: 22 (4): 237–242.

Turner, A., și colab. „*De la izoviști la graficele de vizibilitate:o metodologie pentru analiza spațiului arhitectural."* Mediu și Planificare B: Planificare și Poiectare 28.1, 2001: 103-121.

Teller, J. „*A Spherical Metric for the Field-Oriented Analysis of Complex Urban Open Spaces." Environment and Planning B Planning and Design*, 2003: volume 30, pages 339 ^ 356.

Turner, A., și colab. „*De la izoviști la graficele de vizibilitate:o metodologie pentru analiza spa'iului arhitectural." Mediu și Planificare B: Planificare și Poiectare 28.1*, 2001: 103-121.

Turner, A. & All. „An Algorithmic Definition of the Axial Map." *Environment and Planning B: Planning and Design, 32(3)*, 2005: 425-444.

Turner, A., „*Analysing the Visual Dynamics of Spatial Morphology."* Environment and Planning B: Planning and Design , 30(5), 2003: 657–676.

Turner, A., „*Depthmap: a program to perform visibility graph analysis*." In Proceedings of the 3rd international symposium on space syntax. Atlanta: GA, USA: Georgia Institute of Technology., 2001. Vol. 31, pp. 31-12.

Turner, A., & All. „*From Isovists to Visibility Graphs: A Methodology for the Analysis of Architectural Space." Environment and Planning B: Planning and Design*, 2001 b: 103–121.

Zhang, M., Kang, J., „*Towards the evaluation, description, and creation of soundscapes in urban open spaces."* Environment and Planning B: Planning and Design, 2007: volume 34, pages 68 ^ 86.

Zhiqiang, W. „*A Survey of the Landscape Visibility Analysis Tools and Technical Improvements." International Journal of Environmental Research and Public Health*, 2023: 1-23.

Ziemann A., Fischer G. „*Adapting a sound ray modelof the atmosphere to simulatesound propagation in urban environment." NAG/DAGA*, 2009: 1618-1621.

Woloszyn P. „*Acoustic diffraction patterns from fractal to urban structures: Applications to the Sierpinski triangle and to a neoclassical urban facade." https://www.researchgate.net/publication/226803526*, 2005: 1-14.

Woloszyn P., Pascal J., Leduc T. „*Towards a sound diffusion characterization in the urban environment - from isovist tool to acoustic scattering indicator." https://www.researchgate.net/publication/249009344*, 2013: Vol. 32. Pt 3.

Woloszyn, P., Leduc L., , Joanne P. „*Urban Soundmarks Psychophysical Geodimensioning Towards Ambient Pointers Geosystemic computation." Euronoise.* Edinburgh: HAL Openn Science, 2009.

Yang. W.,, Jian Kang, J., *"Soundscape and Sound Preferences in Urban Squares: A Case Study in Sheffield." Journal of Urban Design*, 2005: Vol. 10. No. 1, 61–80

CONFERENCE

Dalton, R.,C „*The secret is to follow your nose, proceedings. ”* 3rd International. Atlanta: Springer, 2001. 47.1 – 47.14.

Dalton, R., & All. „*Agent Behaviour Simulator (ABS):a platform for urban behaviour development."* The First International Game Technology Conference and Idea Expo (GTEC'01). Hong Kong: : http://nrl.northumbria.ac.uk/policies.html, 18-21 January 2001.

Gage, S., Ummadi, P., Shortridge, A., Qi, J., and Jella, P. K. „*Using GIS to develop a network of acoustic environmental sensors."* ESRI International Users Conference, 2004: 15–28.

Francesco A., Efstathios M., . Filipan,K., Puyana,v., Östen, R., Axelsson, Kang. J., „*Characterization of the soundscape in Valley Gardens, Brighton, by a soundwalk prior to an urban design intervention."* Conference Paper Euronoise. Maastricht: https://www.researchgate.net/publication/277665578, 2015. 1547-1552.

Hillier, B., and Iida, S., „*Network and psychological effects in urban movement."* Spatial Information Theory: International Conference. Ellicottsville: COSIT, 2005. 25-36.

Ismail M., R., Oldham D. „*The effect of the scattering of sound from building facades on urban noise propagation."* Tenth International Congress on Sound and Vibration. Stokholm: https://www.researchgate.net/publication/290099790, 2003. 1445-1452.

Nyusten, John D., and Michael F. Dacey. „*A Graph Theory Interpretation of Nodal Regions."* Papers / Regional Science Association. Regional Science Association. Meeting 7(1), 2005: 21-35.

Petros, K., et all. „*Visibility dissection graph analysis: Metrics and their role in understanding human behavior at work."* Proceedings of the 12th International Space Syntax Symposium. Beijing: China, 2019.

Pyysalo, U., J. Oksanen, and T. Sarjakoski. „*Viewshed analysis and visualization of landscape voxel models.*" In Proceedings of the 24th International Cartographic Conference, 2009: 9-16.

Turner,A.,. „D*epthmap. A Program, to PerformVisisbility Graph Analysis." 3dr* International Symposium on Space Syntax. URL: http//discovery.ucl.ac.uk./2651, 2004. 9.

Turner, A.,& Penn, A. „*Making isovists syntatic: Isovist integration analysis."* Iin Proceedings of the 2nd International Symposium on Space Syntax. Brazil: Universidad de Brasil, 1999.

Turner, A., „*Angular Analysis*." 3rd International Symposium on Space Syntax, Georgia Institute of Technology. Atlanta: vr.ucl.ac.uk, 2001. 12-25.

WEBOGRAPHY

Dubois D., Guastavino C. *"A cognitive approach to urban soundscapes: Using verbal data to access everyday life auditory categories." https://www.researchgate.net/publication/200045136*, 2006: Vol. 92, 865 – 874.

LAWS, DECISIONS

110-1994, International Comission on Illumination CIE. "Standardization of Luminance Distribution on Clear Skies; International Comission on Illumination: Vienna, Austria." 1994.

110-1994, International Comission on Illumination CIE, Standardization of Luminance Distribution on Clear Skies, and Austria, 1994 International Comission on Illumination: Vienna. n.d.

12913, ISO, ISO 12913-1:2014 Acoustics—Soundscape—Definition and Conceptual Framework, and International Organization for. n.d.

ISO 12913; Acoustics—Soundscape—Definition and Conceptual Framework, ISO 12913-1:2014." n.d.

ISO 12913; Acoustics—Soundscape—Definition and Conceptual Framework, ISO 12913-1:2014; International Organization for." n.d.

ISO, 9613. 1997.