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Development of a new analytical model for the study of the urban and architectural sound ambiance: the topological approach.

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Development of a new analytical model for the study of the urban and architectural sound ambiance: the topological approach

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Abstract
Research in the field of ambiences has clearly evolved in our era, the field of investigation lists all the typologies of space ranging from architectural to urban space.
There are many researches but the relationships between them are minimal, so far we do not have a way to treat or perceive the space as a whole, which starts from the macro environment (urban) to the micro environment (architectural)
In this work we have taken sound as a parameter of the ambience and have tried to see through a literature review how the existence of sound sources is studied in urban and architectural space, in order to verify the existence of correspondence between the various methodological palettes that support sound in different types of space.
The objective is to achieve a sound-based analysis model that could support all types of sound environments, whether urban or architectural, in order to create or improve the ambience.
Keywords: ambience, sound, architectural space, urban space, sound sequence.

1 . Introduction

The notion of space is very complex to define, if we talk about urbanism or architecture, architectural or urban space is studied from several angles, first their conceptions, then their perceptions, and finally according to how they are lived. Nowadays, there is more and more interest in the human experience in both spaces. If we understand it, we can remedy the problems that existed, that exist and that may eventually exist in the future. (J.Y.Martin, 2006)
Architectural space is often dissociated from urban space, it is considered as intimate, interior, private space, unlike urban space which is an external and public space. And between the two spaces, we also find in the work of some researchers a border area that acts as a bridge between the two. Especially since G. Chelkoff et al (1988) considers that the ambiguity of urban space resides in its association with the word "public", being in a public place means that we are not alone, and that there is always the presence of another with us, even in our own domestic space.
For E. T. Hall, among the four distances of communication that are intimate, personal, social and public, the "public" distance is the most distant, the most impersonal, in the sense that, at this distance, it becomes more difficult to distinguish precisely the interlocutor.

Although the links between architectural and urban space seem very close, the link seems to be created between the two through the notions of ambiences. In this paper, we will focus on sound, and very particularly on the sound ambience. Sound as a notion is linked to the sensory domain, it is often treated under two aspects: (i) subjective: which emanates from the appreciation of the interlocutor and (ii) objective: which can be experimental and scientific.
G. Chelkoff and Al (1988) attempt to correlate public space with sound space, emphasizing the social meaning that sound brings to public space. They conclude that public space is defined not only by its spatial morphology, status and functions, but also by its social consistency. And if we take an environmental phenomenon such as the sound phenomenon, we will have to address the problems between design and users of public spaces.
The field of investigation by atmospheres is based on the parameters of the perception of space, and very particularly on the five senses that allow the reading of space. Perception research specializes in one of the two spaces, but the reading parameters will remain the same for the two. In this research, we will try to identify a methodological link between urban and architectural space through ambiences, based on a literature review. This link

will be based on a new methodological approach based on topology.

The topological approach in mathematics is similar to the cognitive approach in the field of ambiances, spatial cognition is based on our various movements and their impacts in space (reactive behaviours).

Many authors such as R. Kitchin (1994) now conclude that spatial cognition and cognitive spaces are not the same thing. The process of acquiring spatial cognition refers to what each subject has in him or herself an image of space that we call "cognitive representation". The cognitive representation is like an explicit and analogous map, even the metaphorical representation is very close to a map. For cognitive representation to be implemented, the place must be visited several times. Topology is based on the notion of the route, the human body in movement crosses points in the route and it constitutes an event on the axis of time. We are looking to see in this paper, how and to what degree can topology contribute to the birth of a new architectural and urban spatiality? And how could topology create a link between architectural and urban space by considering them both as topological space? And could topology, like cognition, develop a new definition of space based on spatial deformations?

1.1. SOUND as an essential component of architectural and urban space:

1.1.1. The SOUND in Architecture:

Architecture is the modulator of the space occupied by sound, and if we try to define it based on sound, we can see that it is the sculpture that lies between vision and sound. From this point of view, architecture is considered as a solid that receives the impulse of collisions and transmits it to other particles, thus producing affected sound waves (Alla Ching-Shan Cheung ;2005)

Contemporary space has allowed us to discover a new concept in architecture, what researchers call "Sound art" linking architecture and sound in an artistic way, based on the triad of space/time/body movement. As a result, sound is very much linked to movement.

There are four main components of the sound/architecture studies, which are presented by A.C.S Cheung (2005) as follows: (i) the dynamic relationship between sound and architecture: he cites the work of Murray Schafer and Leitner who consider that the ear as an organ of perception must be engaged in architectural design just like the eye, (ii) sound architecture: he cites Le Corbusier who considers that sound, once transformed by space and matter over time, brings the user a new experience different from what he has lived previously. he explains this principle in his design of the Philips Pavilion, where he has also designed scenarios of overlapping sound inside that make space users perceive music in different ways depending on where they are sitting.

Pierre Schafer (1968) shares the same vision, by proposing a dissociation between the source and the sound it produces, he highlights the notion of the "its object", he calls for an appreciation of sound by its essential acoustic properties and not in relation to the object that produces it.

1.1.2. The sound in Urbanism:

G. Chelkoff and Al (1988) deal with urban sound in its entirety in their research, based on a general observation that the use of the notion "public sound space" is not the most appropriate to talk about sound in the urban context. the latter is not only a spatial dimension but also a temporality. G. Chelkoff and Al, (1988) find that the association of the adjective public with the word space can cause misunderstandings. He suggests that we should rather talk about "collective sound dimension" or "sound urbanity".

It is about understanding and studying sound in a public sphere. They will set two objectives: i) the first being to compare between the different old and recent public spaces by highlighting their specific sound characteristics, ii) the second is to highlight the possible contradictions that spatial planning practices can create with sound experience.

The researchers (G. Chelkoff and Al, 1988) therefore propose four essential themes to be addressed separately or in interrelation: i) the perception and sound qualification of places, ii) the spatial-phonic delimitation, iii) the sound memory and temporality the auditory perception is entirely attached to time, thus "sound is qualified time" (Augoyard, 1991), iv) the sound modalities of public relations, also called the sound community.

In this research, the results are presented in the form of a sequence reading, the sequences are chosen according to several parameters and are recorded and presented to the listener as follows: i) the local sequences, those of the public space closest to him, ii) the general sequences that will make him hear public spaces that he may not know. (G. Chelkoff et al, 1988) Analysis of residents' reactions to the sequences provides insight into which sounds are perceived and which are considered appreciated for use in future urban sound design.

According to S. Marry (2013), sound can only exist if you have a sound signal, through a signal the sound is heard and perceived. Sound is represented in many forms, its representations are personal, but

also depend on the context and society. Thus sound will be a function of the ambient rules of each society (technical, legal, moral), and of values (ideological, emotional, economic) and signs (linguistic, mathematical) that form a model. She cites the example of Aubrée's (2002) reference model, which finds that the judgment of the sound environment is variable, this is due to the impact of the cognitive system and the representations we have on perception. Before studying perceptual expressions, it will therefore be necessary to research the representative foundations. Thus the evaluation of the general urban atmosphere is carried out by each individual, using these previous experiences, for this purpose the whole background that the person has, in the form of sound and visual images, determine the perceptions in situ as soon as one begins to travel through the city. (Marry. S, 2013)

It also refers to Ledentu's (2006) work, which states that the perception of the environment is not only reflected in an assessment of objective physical characteristics, it also depends on our expectations, our representations, social norms, or our emotional state affect our perceptions. This dimension of urban sound is both personal and shared. (Marry. S, 2013)

Corsin Vogel (2013) proposes an artistic approach to studying sound, it takes charge of "sound semantics" and extends over three stages: i) giving listeners a daily sound experience, ii) reactivating their own imaginations, iii) letting listeners appropriate the sounds broadcast in order to ultimately fill in appreciation charts according to their listening. (C. Vogel, 2013)

1.2. Sound topology in urban and architectural environments:

1.2.1. The topological approach in urbanism and architecture:

The topological approach is very old in architecture, it appeared during the last century to solve one of the most complicated urban planning problems (Corcuff, 2007). Topology in urbanism is based on the existence of spatial sequences of a temporal nature, the succession of their sequences, their homogeneity or heterogeneity refers to a topological characterization. The temporal and spatial sequence is used to construct mental images to understand and define the physical world around us. Visual perception is achieved through body movement and the reception of multiple points of view. Although the acquisition of the visual stimulus is done through the movement of the head and eyes, it is nevertheless a fast capture of non-continuous still images, fragmented into samples.

Moreover, Philippe Panerai (1985) did not mention topology in his book, but he spoke about sequence, he defines sequential analysis as the identification of the elements that constitute the landscape, and which can only be conceived in a direct analysis in the field. The city is apprehended from the inside by a succession of movements. Both semantic unity and technical breakdown, the notion of visual sequence comes directly from cinema. Sequence is a term in cinematographic vocabulary referring to a series of continuous shots that form a narrative unit. It is generally a unit of time (and/or place). Applied to architecture and the city, sequential analysis makes it possible to study changes in perception in a route.

For an observer moving in a given direction, a path, or some path that has been decided to study, can be divided into a number of sequences; each consisting of a succession of "planes" in which the visual field is determined in a constant way or undergoes minimal modifications. Each plan can be characterized.

now moving on to architecture, The theoretical basis of the topological approach in architecture and the emergence of this notion had been addressed in several works, first of all topology as fundamental elements of the formal aspect of architecture, which brought a new way of classifying architectural works according to the external form. (M.H, 1997)

Guiseppa.D.C, later in 2001, states that the topological approach in architecture has materialized under two currents: that of deconstructivists and that of the avant-garde. (Saraoui.S, 2018) However, we have noticed that all the works that deal with topology often expose the formal problems of architecture or the mathematical answers that architects try to find to the formal problems of their projects. This means that no topological theory concerning architecture has been developed so far.

After reviewing the various definitions of topology, it was concluded that it is defined as the act of moving over a period of time (the time of the route). The dynamic movement of the body crosses time creating points, successively, throughout the journey (duration). This point, once created, is an event (Saraoui.S, 2018).

It is therefore considered that it is possible to define topology, from an etymological point of view, according to two terms: (i) transformation which refers to deformation and metamorphosis, (ii) continuity which means a continuum whose origin is geometric. (Author, 2011)

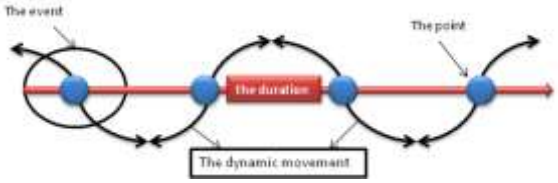


Figure 01: Synthesis of the topology definition

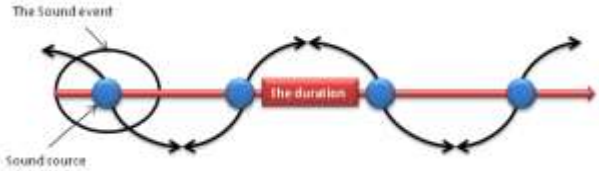


Figure 02: Definition of the sequential analysis for the sound ambience

In architectural space, if we take into consideration the different perceptions, the definition of space moves from geometry to sensation, there is a very varied range of studies on the perception of space, and all studies converge towards an essential point summarized by A.C.S Cheung (2005), which is to consider space as a fixed or constantly moving reception point.

If we focus on the user and his movements without space, the user in this case will be a large ear in perpetual movement in a permeable environment, this description defines sound space in the form of points and temporary lines that unfolds in time as in the case of music, and this definition will apply to any type of space. (Bernhard Leitner)

1.2.2. Sound topology:

Sound topology also appears in the field of music, it is described by Charles-E Platel (2007), in his book Musique imaginary, as a revealing notion of discontinuities or stops in sound composition. It was Nicolas Schöffer (1972) in his proposal for the "cybernetic city" who initiated the notion of audible or sonic topology, sound becomes for Schöffer a material within space just like time or light, it is the centre of all reflections around space.

The topological approach to sound has not been cited in the work of architects dealing with architectural and urban space, with the exception of Charles-E Platel's utopian writings (2007). However, in analysing various research studies that deal with sound, we have noticed that in terms of methodology, the notions of sequential analysis, sequences and route are often present.

1.2.2.1. Architectural sound topology:

a) A formal conceptual sound topology:

We have not found in research on architectural space those that deal with sound topology, while sound is often associated with the architectural envelope that encompasses form and materials, adding architectural routes to it.

Jean Philippe Velu (2013) who is an architect and musician had summarized the different ways of combining architectural space and music (a topological sound) as follows:

- An inspiration (direct analogies): he cites the example of Libeskind, analogies are perceptible by plays of material, scale, light. And the sound topology will influence the final shape.
- A correlation between the design methods: he cites the example of Steven Holl where the architect had tried to have his architectural work interact with the musical work of Béla Bartok, the reasoning can be summarized in the following equation: Material x sound=time ⇔ material x light=space.
- The direct translation of the score/architectural project: he cites a utopian example, that of high-rise buildings, which he considers to be notes, and staves are traffic lanes.

Through these examples, we will realize that there are architects who, through architectural compositions close to sound topologies, seek to create a new and different perception of time.

(b) A sequential sound topology:

We can also mention a work that we have developed on sound topology, or we have created from the definition of topology a definition of sound topology, which is based on the notion of the route and the sequence. Based on the existence of sound sources in an interior architectural space, the change of ambience and the differences that can exist between successive sequences refers to the creation of topological sound discontinuities. We then verified the existence of these discontinuities through some thirty European museums. The choice of museums was made on the basis of several selection criteria, and the tour guide was considered as a sound source in perpetual movement. the sequences that characterize the change in the sound atmosphere according to the movement of the body are presented in the table 01 and the figure 03 (for the case of the Salzburg Historical Museum). This study helped us to bring out the sound topologies, and through simulation we were able to visualize them. (Saraoui et al, 2018)

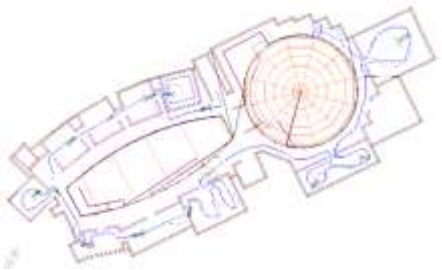


Figure 03: The route and sound sources of the museum the Salzburg Historical Museum

Table 01: Sound sequences of the museum the Salzburg Historical Museum

Results	Sequences	Results	Sequences	Results	Sequences
	S09		S04		**Route**
	S10		S05		S01
	S11		S06		S02
	S12		S07		S03
	S13		S08		S04

1.2.2.2. Urban sound topology:

a) Represent by mapping: map the topology

The use of sound topology in urban planning is often linked to the representation of sound topologies, this often-graphic representation is done by maps. The first work we analysed is that of Mohammed Boubezari and Al (2012). This work seems interesting insofar as we are trying to give meaning to the signal represented in the way closest to its perception in situ. The challenge was to develop qualitative sound maps, which focus on the situation of the identified and measured sound sources taking into account the audibility limits of each. Just overlay the sound topologies obtained and you can quickly read the sound landscape.

Olivier Balay (2006) had also mapped sound using SIG-chAOS, sound has taken on a temporal dimension in his work, in which it appears, changes and disappears. This method provides an urban sound map that can be populated with photos and other information such as soundtracks recorded at any time.

(b) Sequential analysis of the source, sequence, urban route:

The notion of the route is often present in the various research studies that deal with sound. Deferville (2004) suggests in his work to start by determining the route to be studied, and presenting on it the sound sources created or existing on monitoring maps according to their signals and their impacts on the given environment. This monitoring will be done through experimentation or simulation. Simulation is much easier and more revealing than experimentation.

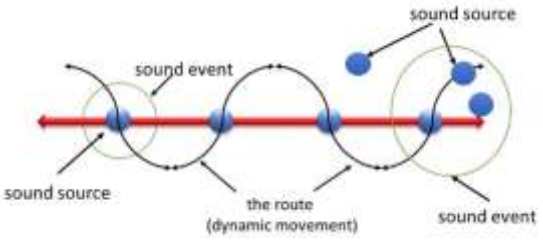


Figure 04: Definition of the sequential analysis for the urban sound space

Sahraoui. N (2006) proposes to study the sound identity of Constantine's medina by collecting the qualitative and quantitative aspects of the sound atmosphere on the maps of the routes she has chosen. The principle is to determine the topographical limits of the audibility of the sound landscape, based on the different sound sources in the routes in question, which will be composed of several sequences.

The principle of the research is to start with the commented route method, which makes it possible to verify the existence of sound discontinuities in the urban environment, what we call here "sound topologies". The method in question will describe an existing situation or predict a projected situation as an urban development project, demonstrating that the topography of the sound landscape is possible.

2. The method and material:

It should be noted that our work does not deal with the acoustic quality of space, which deals with the

relationship between sound and materials in order to interpret them for a better acoustic understanding of space. Our study is theoretical we will not compare values to standards, what interests us is the behaviour of sound in an architectural or urban environment, and how through topology we can interpret it.

2.1. A methodological merger or rapprochement: (Steps of sequential analysis)

We have compared the few examples cited in the introduction section, through their methodological principles, in the architectural or urban space, and we have summarized them in the following table:

Table 02: summary of the comparison between urban sound analysis methodology and architectural sound analysis methodology

Sequential analysis step	Urban	Architectural
Identification	- Identification of the space and its morphological characteristics	- Characteristics of the conformation shape and materials
Space to analyse	- Square - A Route (commented if it passes through several sequences)	- Route (movement of the sound source itself or of the body between several sources)
The sequences	- Several external sound sources	- A single fixed or moving sound source - Several isolated sounds source - Several sound sources in the same space
Complementary analysis	- In situ analysis - Descriptive method - Predictive method	In situ analysis - Descriptive method - Predictive method
Representation	- Mapping sound	- Obtaining a detailed representation of the behaviour of the sound wave - Representation of the sequences in a shot

There are similarities between the methodology used in urban and architectural design, in the part where researchers focus on a route in which there are sources, researchers refer to the existence of sequences which is for the most part a sound event of sequential analysis. The difference is in the additional analysis that either to have the acoustic quantities, or to visualize the sound sequences. But the methodological principle will remain the same.

2.2 A new analytical model for urban and architectural analysis:

The following is a discussion of the detection and identification of sound topologies. The notion of a route seems to us to be the most appropriate from the outset insofar as it is similar to the notions of movement specific to topology, and of walking in the urban and architectural environment. Le Corbusier had highlighted the fact that architecture is a journey, with its concept of an "architectural walk. (Panerai Ph. And al,1999)

It is obvious that the reading of sound topologies requires the construction of a new conceptual model, its role is to support the main components and their sub-components that concern the sound wave and the architectural space and/or the urban space.

It is therefore a question of: 1) defining an application space and taking into consideration all its components, it is even possible to model it, 2) identifying the sound sources and reporting them on plan by measuring their acoustic quantities (for further analysis), 3) the additional analysis: which will have as objectives the description and visualization of the sound topologies (In our case the additional analysis will be done by the Ecotect 2011 software).The first two steps are sufficient to talk about sound topology, except that the sound wave is invisible we cannot know where the limits of audibility will be and therefore the third step is necessary to visualize each sound sequence so that we can then superimpose them to have a sound topography of our case study.

Sound as a spatial component, whether it is in the urban or the architectural (if quality is ignored), is described by several elements that are highlighted by the simulation since sound is invisible and are: the characteristics of the sound wave and sound (Jouhaneau, 2003). The first element concerns the sound source, and the second is the space to be analysed architecturally or urban. For the urban area, the palette remains very varied, we can cite as examples the walls of the sequence, the sound obstacles, and the different objects belonging to the space and which have an influence on the sound.

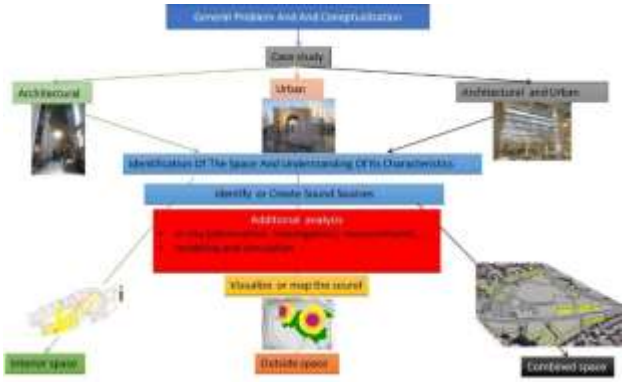


Figure 05: the methodological principle

2.3 The case study:

Our case study is an urban park located in the city of Bejaia, Ali Vava Leisure Park is characterized by the existence of a large lake inside, an animal corner, a restaurant, and several rides for children, but also some equipment managed by the Ministry of Culture, we mention in our work a small craft museum, the museum in question has works exhibited for sale, and it is a rectangular space that has two doors all the time open. We will choose one of the routes taken by the park's users, which is supposed to be an urban route, and which passes through the museum and then emerges, the objective is to test the method of sequential analysis by passing from the urban space to the architectural space, by subsequently checking the resulting sound topologies.

Figure 06 : The location of the Ali Vava leisure park (google earth map worked)

Figure 07: photos on the route and the handicraft museum photos on the route and the handicraft museum (source: Facebook page of the Ali Vava leisure park)

3. Results and discussion:

The space in question consists of all the characteristics of a topological space to be analysed, first the route from urban public space to an architectural space and then the urban space. This gives us a combined space to analyse.

3.1. Sound sequential analysis:

This step is the most important of all the previous steps, we first made an in-situ observation to complete the missing information, first the lived itinerary, the one most pedestrian often use that we drew in white color.

It was noted that we have identified for the urban space the fixed sources (a numbered blue circle) that are often music kiosks where we sell the ticket office for children's playgrounds (1,2,4), the same musical device for the 3rd sound source that is located in a restaurant. As for source 05, it materializes the sounds of bumper cars. For the sources (6, 7), it is the sources of the inner space that materialize the guide that explains the artisanal works on display. As for sound source 8, it materializes sounds that come from the karting field.

We have noticed that the route is divided into 5 zones (the black squares): i) zone 01: with the first four sound sources very close, ii) zone 02: the source 05 which is always outside, iii) zone 03: the craft museum, iv) zone 04: karting.

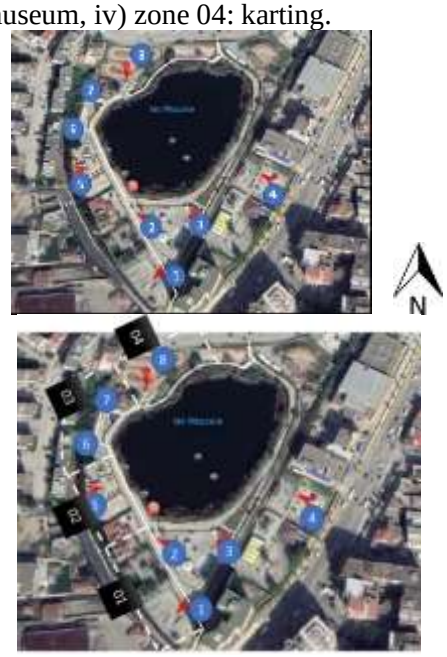


Figure 08: Reworked google earth map showing the route, sound sources, and sequences by area

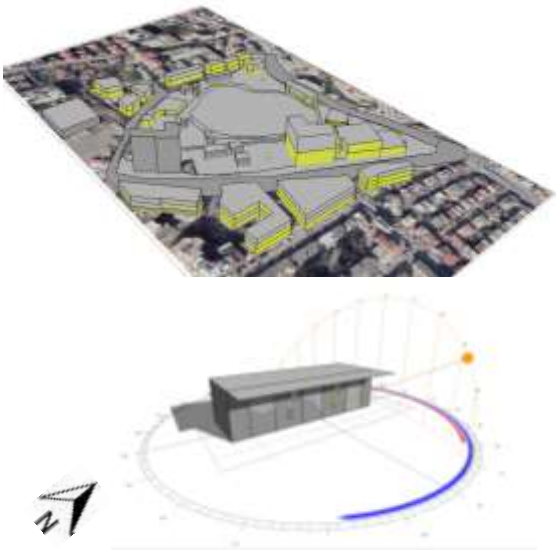


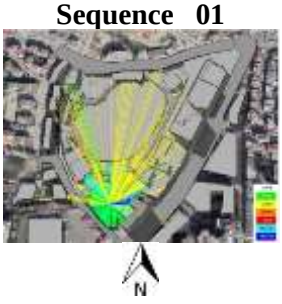
Figure 09: Ali Vava leisure park site and museum modelling

3.2. Visualization of sound sequences:

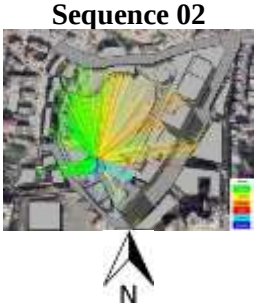
The urban sequences are very visible, and include the whole range of characteristics of the sound wave, there is just the sequence 05 which has many urban walls and a very low acoustic size. For the sequence 06 and 07 they are interior sequences and as during the day the two doors of the museum will be opened the interior space will be affected by the sound sources outside, but the sources inside will not be active at the same time since the guide is talking at the entrance and exit of the museum.

Table 03: synthesis of the sound topologies of the urban site that integrates the craft museum with the lake site

Sequence 01

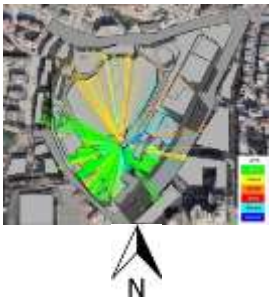


Sequence 02

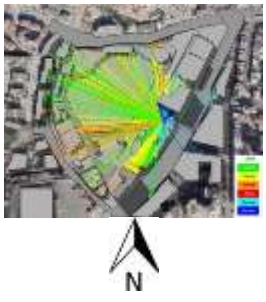


Sequence 03

Sequence 04

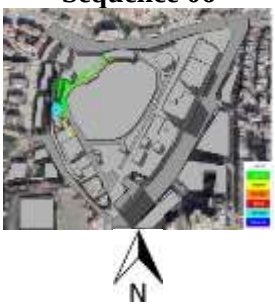


Sequence 05

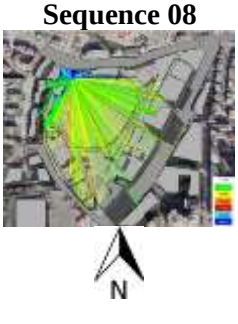


Sequence 06

Sequence 07



Sequence 08



3.3. Sounds topologies:

On this map we have combined different results of the sequential analysis, we will call this map, the map of sound topologies, since it allows us to see all the sound sources and the sequences that they generate.

The topologies may possibly exist, they are in direct relationship with the listener, who should in favourable conditions, move on a route that is as simple as possible, in our case the route connects between two entrances, it crosses the Ali Vava leisure park and passes through a small equipment that is the museum, in which we the listener will stop to appreciate the works exhibited, listen to what the exhibition guide will then tell him continue his route. The sound topologies originate from the listener's first movement.

The result of the method showed that it will be possible to map sound topologies by two methods first of all the topography of the sound landscape, which will allow to quickly read what makes up a sound landscape within the topographical limits of its audibility. As was the case for Bouazizi's work except that this time by integrating an interior space

into the urban space, and did not by staying just in the urban.

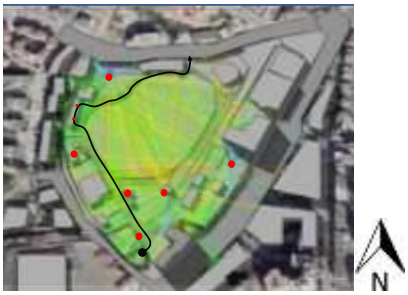


Figure10: the synthesis of the sound topology of the lake site of the Ali Vava leisure park

Conclusion:

The analysis of the sound ambience is very important in the architectural and/or urban environment, sound is like light, it is part of our daily life and from a cognitive point of view, it helps us to acquire representations of a given space, if the mental image is very close to the visual, it will be the same for the sound.

Cognitive images related to sound are produced by the listener's movement along a route in a given space, or the existence of sound sources of variable intensity creates sequences, these close or distant sequences create areas of audibility, these areas are purely sound events of a highly variable nature.

The disparities and rapprochements that can characterize the sound sequences of the same space, constitute etymological points of view, discontinuities or continuous sound transformations, which we can call thanks to the definition of the topology of sound topologies. Sound topologies exist in architectural and urban spaces, and are not often highlighted.

In this paper we have realized that just like cognitions, which contributes to the birth of mental representations in the user of space, topology can create a new spatiality within space, this spatiality has the role of bringing out sound sequences and studying them in time (present, past, future).

We were able to obtain the topology thanks to the report that links the listener's route and the sound sources, we can say from a methodological point of view that there is not much difference between the application of the sequential method of architectural space to the urban, for this reason we can combine the two spaces for a better treatment of the general sound environment.

The topological approach in sound environments, helps to isolate the sequences, and through simulation we can have for each sequence a point visualization (related to the source), this visualization will allow us to clearly see the limits of audibility related to each source, it can start with the urban and go through the architectural or the opposite. The assembly of the simulation results of all the sequences on a single map will give an idea of the audible limits and detailed characteristics of the sound in the area or route to be analysed.

This approach will make it possible to treat each sound sequence separately, then all the sequences in their entirety, we can improve by this approach: i) existing situations, by treating the intensity of the source, or the urban or architectural acoustic walls that characterize them, ii) Study previous situations of the sound environment (those that existed in the past), iii) propose for future designs a sound topology that we find interesting (already exists), or create a new sound topology that would meet the requirements of the space and its users.

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