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Abstract. *In a context of an international interest for the question of urban spaces accessibility for elderly, we tend to construct an experimental protocol correlating data issues of commented walks, psychophysiologic measures of stress level engendered by the crossing of some dangerous urban configurations and signal processing. This treatment is declined under multiple graphic representations allowing detecting in two dimensions those situations of danger. Through this protocol, we intend to characterize the informational content of urban sonic ambiances. The emergence of sound events that may announce a dangerous situation can be represented and we can guarantee to seniors with hearing loss a serene using of the city.*

Keywords: sonic ambiances, presbycusis, segmentation, danger, stress level

Introduction

Nowadays, the concept of ambiance is recognized as an operative entity in urban accessibility and social practices unfolding in the city. The human perception of the environment can not be reduced to an addition of physical phenomena but it's related to a complex interaction of physical, physiological, cognitive and sociological factors. Through these interactions, urban designers are required to find a compromise between the creation of spaces and its social usage induced by such design. Such compromises are easy when we talk about "normal" person whose perception of related ambiances is not affected by any disability. However, the situation requires more analysis in the case of disabled perceptions.

As a great percent of persons age, many are experiencing physical and cognitive problems. But we can't deny sensory impairments and precisely the difficulties due to hearing loss, however slight they may be. Indeed, this aging-associated hearing loss, called "presbycusis", is the first reason of accidents in the city in case of old pedestrian (Renes, 2007). Loosing sound discrimination may causes difficulties of interaction with the environment. It results in many situations of disabilities faced by older people with hearing problems evolving in town like dangerous situations due to not hearing sound alarms of cars while crossing roads. As the progressive loss of high frequency perception of sounds changes the appreciation of distance and location of a sound source, the mobility-related security issues are very clear in case of old pedestrian with presbycusis.

Experimental protocol

To detect graphically situations of disabilities faced by seniors with presbycusis in urban spaces, we seek in this paper, to draw parallels with some perceptual features of sonic ambiances, visual representations of sound scene segmentation, and psychophysiological measurements to reflect human stress levels in such situations.

Identification of accident-prone urban configurations

We have carefully selected "critical" fields for our experiments where old pedestrians face situations of danger. With a reference to the international interest given to the safety of old pedestrians in the city, we have applied a model usually used in the field of accidents studies, known as "prototypical accident scenario"[1] (Fleury, 2001). A prototypical scenario is a prototype of accident process corresponding to a group of accidents which show an overall similitude in terms of the sequence of events and causal links, throughout the successive stages leading to the collision. The investigations have been based on detailed analyses of accident cases of old pedestrian in Nantes (between 2000 and 2008)[2].

Through the consideration of those scenarios, we grouped similar cases of accidents according to the studied model and we identified three urban configurations with a high level of old pedestrian's accidents with similar scenarios: classical crossings, crossroads and traffic circles.

We selected then three fields in Tunis for our study where experiments were carried out:

- The first urban class is associated to classical road intersections; we chose an area in Tunis called *Beb-El Falla*, where the traffic jam is high due to a marketplace near it.
- The second urban configuration represents a traffic circle, which is a complex urban structure that requires from an old pedestrian special concentration to cross it. We chose a typical area in Tunis with such configuration called *Habib Bourguiba's Avenue*.
- The third and last urban field was a crossroads at the area of *Lafayette* in Tunis. The crossroads we chose is regulated with standard traffic lights.

Commented walks and measures of stress

Our target population is represented by twenty seniors with presbycusis, whose hearing loss evaluations via audiograms were possible. Each person performed a commented walk (Thibaut, 1998) in each accident-prone configuration previously identified, focusing on what he/she hears. The person had to provide permanently spatial cues.

During the commented walks, each subject was wearing a wireless biosensor that measures the electrodermal activity which tracks the person's stress level (Healey, 2005); therefore providing an efficient method to detect stressful events even if the subject did not verbally express that during the commented walks (Ghozi, 2011). The biosensor measures emotional arousal via skin conductance, a form of electrodermal activity (EDA) that grows higher during states such as anxiety and lower during states such as relaxation. The biosensor achieves this by passing a miniscule amount of electrical current between two electrodes in contact with the person's arm wrist which yields a measure of the skin conductance (in µSiemens). When using this biosensor, it is important to fix it correctly and insure it is on at least 5 minutes adaptation time. Those walks were carried at periods of a high traffic and during daytime.

1. This model, developed by INRETS in France, consists in classifying accidents according to the similarity of the events and causal links between them that lead to the accident.

2. In the city of Nantes.

Segmentation of sound scenes

The last level of analysis will own to the field of signal processing by applying to each sound scene recorded during the walks an algorithm of segmentation (Ghozi, 2007) that computes the similarity between any two frame vectors of the signal. The similarity matrix is a method for visualizing sound structure via its acoustic self-similarity across time, rather than by absolute characteristics. This matrix contains the quantitative similarity between all pairwise combinations of frame vectors. The result of such an operation is a textured grayscale image where we can see and localize the modifications of sonic ambiances and the emergence of a sound event. The different steps of the segmentation are represented by Figure 1:

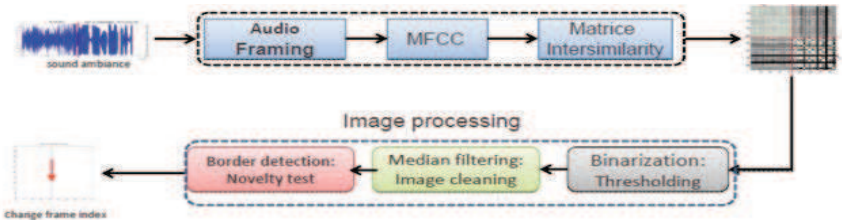

Figure 1. Algorithm of sound scenes segmentation

Results and analysis

By carrying out a filtering of all the sound sequences recorded during the twenty walks realized in each urban configuration, we obtained “filtered sequences” ready to be analysed through the algorithm of segmentation and to correlate with the graphic representation of the electrodermal activity. We used to filter the sound a hearing loss simulator that allows simulating the hearing loss based on the measured hearing threshold through the audiograms of our twenty seniors. So, we obtained 4 levels of sound representations (Figure 2):

- Electrodermal activity level (1)
- Temporal level (2)
- Sonogram level (3)
- Segmentation level (4)

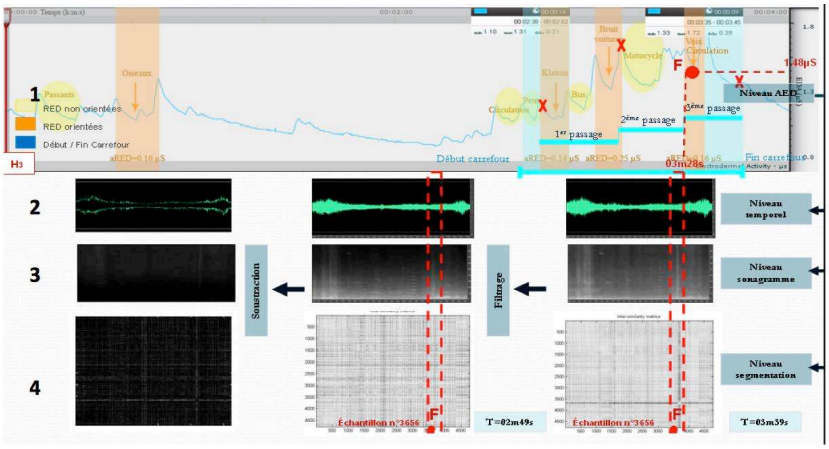

Figure 2. Correlation between four levels of sound scene representations

When the old pedestrian crosses the road and he can't identify a near sound of a car's horn, we analyzed this specific sound scene with the segmentation's algorithm. The obtained grayscale plot represents the segmented scene where each pixel is given a grayscale value proportional to the similarity measure: the higher the similarity, the brighter the pixel. Thus, we proceed to a definition of the temporal coordinates (point F, Figure 2) of the electrodermal reaction that express a stress during this task of crossing. Then we associate them with the segmentation of the sound scene through a scanning of the obtained inter-similarity matrix. Finally, we could accurately determine the number of the sample of the sequence corresponding to the exact moment of the emergence of the dangerous situation that hasn't been identified by the presbycusis senior. Thanks to this correlation, these "textured images" are a relevant graphic indicator for architects whom work on city's accessibility for presbycusic seniors to avoid such situations of danger.

Conclusion

In this study, we focus on audio altered perception of sonic ambiances, and on how an architect or an urban designer can integrate such specificities by proposing an innovative graphic method to detect emergence of sound events that may announce a danger on the road for old presbycusic pedestrian. Through correlations between physicals, perceptual and psychophysiological levels of translating sound scenes, we were able to qualify the informational content of the studied sonic ambiances, to detect modifications of sound scenes which are not perceived by elderly with hearing loss and to represent them through a new graphic method which is the segmented images. Thus, we can work to provide a safe city to seniors with hearing loss.

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Faten Hussein (faten.hussein@cerma.archi.fr) is an architect and a Ph.D graduate student at CERMA (School of Architecture, Nantes). She worked on a project that focuses on the identification of situations of disabilities faced by seniors with hearing problems evolving in town. Her interest is both on the altered perception of the complexity of sounds in the city.