REAL-TIME SOUNDSCAPE SIMULATION

A method for real time spatial analysis of sound via modelling in a CAD environment, based on acoustical measurements

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Typical modeling systems for spatial analysis employ data that represent the visual part of a landscape (e.g. relief and morphology), combined with other data about specific attributes (depending on the aims of an application). Thus, in a modeling environment, each place is described by a variety of properties that are not always visible. More of those "hidden" properties require special sensors and/or instruments to be captured and sometimes make their presence evident through human senses, such is sound.

The present study takes advantage of wide spread technologies (such as GPS, VHF telecommunications and field sensors) and methodologies that are commonly used in telegeoprocessing – telegeomonitoring in order to simulate an existing acoustic environment. The aim is to acquire real time data about the sound (referenced to a particular area) and manipulate them in a CAD environment with purpose to visualize the sound influence in a specific landscape. Specifically it is proposed a method that transfers spatial data (collected from the field), directly into a modeling system (in the office, or in situ). In sequence the data is processed adequately to feed the modeling system that describes the current sound intensity of a place.

KEYWORDS

Environmental Simulation, Soundscape, Real-time data acquisition, Real-time 3D modeling

INTRODUCTION

Sound acts as a dominant factor concerning our perception about the environment (physical or human-made). Consequently the study and analysis of an "active" space should take into account the influence of sound. On the other hand (in the terms of modelling) "active" means that something is changing and has to be managed over time; that includes sound.

The study of sound in accordance with landscape is not something new (commonly used for noise mitigation). The relation between landscape and its sounds is described by the term soundscape [3]. In this manner sounds are treated as spatial events, which (in spatial analysis) are co-processed with typical landscape- geographic features. Taking into account that an "active" space is changing continuously as various events are happening (fig.1) there is a need to monitor this space through time using real- time models.

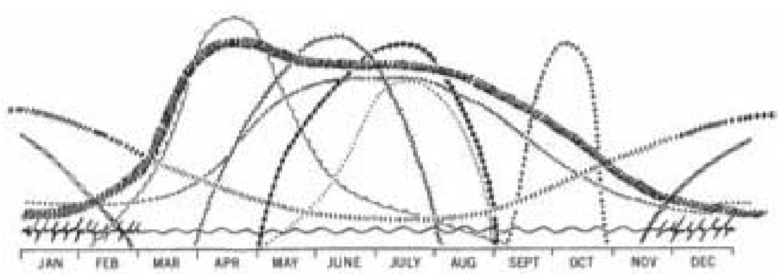

Figure 1: An example of the cycles for a natural soundscape showing the relative level of sounds during various epochs [4].

This paper describes a technique that feeds in real-time a modelling system with sound data (Sound Pressure Level – SPL) from selected points over a place of interest. The measurements are taken by a surveyor in the field and they are transmitted towards the modelling system where they generate the model. Repeated measurements are refreshing the model.

METHODOLOGY

Each field survey for spatial analysis consists of two parts, concerning the data acquisition, positioning and measurement. The first is necessary to reference (more likely georeferance) the second. Furthermore collected data are managed adequately by a model in order to get results. When this model operates in a graphic environment (e.g. CAD or GIS) the product is a map. In this case the whole process is done in real-time resulting in an animated SPL map.

Acquisition Method

The process is divided in two steps. Primary, data is collected in the field using a combination of devices (fig. 2) that includes a hand-held GPS, a digital SPL measuring instrument (sound level meter) and a special VHF radio which turns the digital measurements into data packets and then it transmits them as voice signals (just like the telephone modems).

Figure 2 : Schematic combination of field devices

Primary the position is acquired from the GPS receiver (Geographic Coordinates) and the relative measurement for the SPL is taken from the sound level meter. The above combination (data from GPS and sound level meter) forms a data sentence with the following structure:

… SV2BZY,**38317500022587700**,/[,2,2,,,**048372**, …
(bold letters indicate Latitude: 38º31,75’ N, Longitude: 022º58,77’ E, Height: 048 m, SPL: 62,2 dB)

The structure of such data sentences is based on the syntax for packet radio communication, which is very common between radio amateurs who participate in the Automatic Position Reporting System (APRS) [1]. Sequentially each of those sentences is transformed in voice signals (like the ones from data modems) and is transmitted towards the modelling system. This process is done automatically with a radio transceiver (KENWOOD’ s TH-D7) that contains a special unit for this purpose (known as Terminal Node Controller or TNC).

Sequentially, on the second step, the signal is received by the system (using another radio tuned in the same frequency) and right after it is transformed (decoded) in a digital data sentence that is stored, as a new record in a table. This table is used to provide the model with data. Each one of the records contains the geographic coordinates, the recording time and the measurement (taken by the digital sensor). So, the table forms a time-series of SPL data for various points across the area of interest (table 1).

Record	Coordinates (GPS)			Time (GPS)	Measurement
R	*X*	*Y*	*Z*	*T*	*M*
1	x1	y1	z1	t1	m1
2	x2	y2	z2	t2	m2
...					
v	xv	yv	zv	tv	mv

Table 1 : The structure of the table of measurements.

Every time the system receives a new sentence, the model is regenerating itself leading in the creation of a dynamic thematic map. According to the movements of the surveyor (in the field) the model (in the system) changes.

Modelling Method

The proposed method transfers in real time spatial data into a specially developed CAD modelling tool in AutoCAD environment. These data may be measurements of randomly selected positions (in the physical environment) or in-line points (across a linear geographic feature: e.g. roads, paths, rivers, railroad etc) or even over a net (specific knots and segments of a network: e.g. urban environment or road network). The sound pressure level (SPL), of these positions, is gained via a connected sensor such as a sound level meter.

The modelling tool is realized with the Visual LISP and Visual BASIC programming code and it is adapted to the AutoCAD platform. It consists of two components [2]; the first one has to do with the recuperation of the rates and the second one with the final calculation (fig. 3)

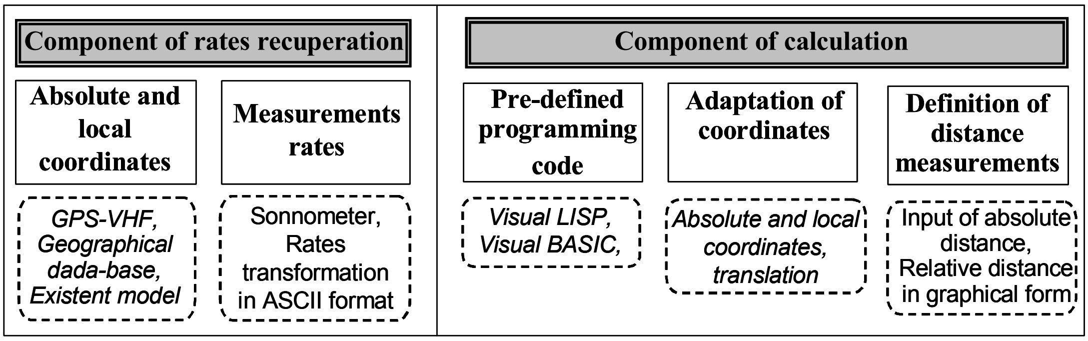

Figure 3: Schematic description of the components of the proposed modeling tool

The first component permits on one hand the rates recuperation of the absolute geographical coordinates in ASCII format and in real time method which is described above. The proposed tool defines local coordinates, if necessary, in order to adapt the absolute geographical coordinates in a pre-existent model in which all the real measured surfaces will be adapted in a model format. On the other hand, the component retrieves the rates of the sensor in order to treat them later from the other component.

The second component is based on a pre-defined programming code and it concerns the necessary calculation in order to adapt the virtual space via transformations of translation and modelizes the final adapted model surfaces in comparative simulation with the rates of the acoustical measurements in real time.

Simulation Method

The proposed system modelizes a spatial mesh representing SPL rate peaks of the selected positions in order to simulate a "sound map" so to be superimposed on other traditional geographic features. The resulting product of this model can be used in combination with other spatial information to define the "soundscape".

The calculated rates of the Sound Pressure Level (SPL) of the connected used sound level meter, can be simulated in a central frequency (e.c. 1 kHz) or in a usual frequency octave (e.c. 125 Hz – 4 kHz). The model surfaces are modeled in real-time option, according to three types of measurements and relative types of simulation: a) randomly selected positions (in the physical environment) where there are not so many obstacles (specially in environments with ecological interests), b) in line points (matching the human movement across a linear geographic feature: e.g. roads, paths, rivers, railroad etc) and c) positions over a mesh like selected knots and segments of a network: e.g. urban environment or road network) (fig.4).

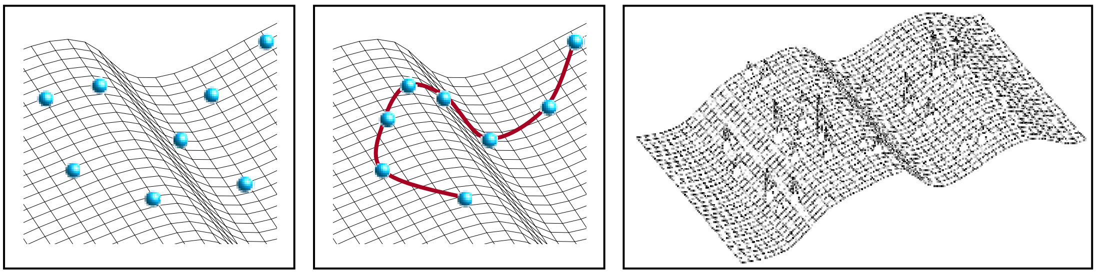

Figure. 4: Theoretical schematic simulation of the three types of measurements

The theoretical, for instance, approach of the simulation method, is associated with three parameters: the coordinates (Longitude, Latitude and Height), the rates of the sound level meter and the time (moment and length of measurement period) (fig. 5).

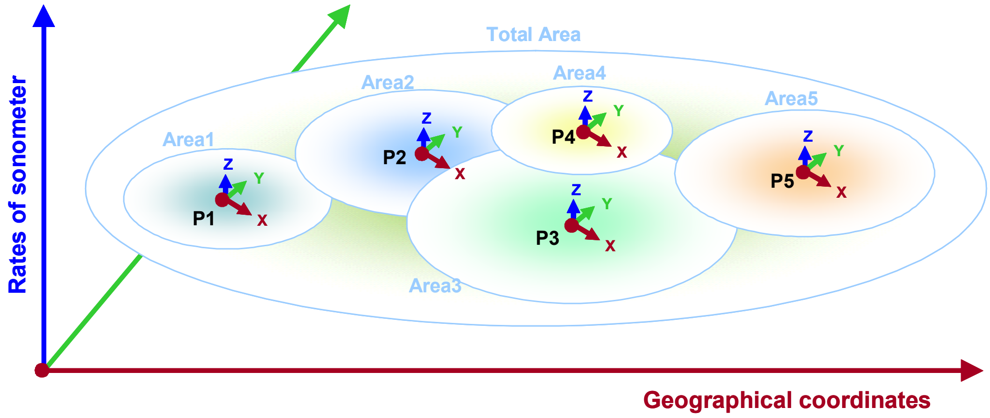

Figure. 5: Theoretical schema of the associated parameters with the simulation method

On one hand, every measurement, in each position (Px) covers a distinguish area (Area x) where the rates of the SPL measurements are quite the same (depending on the instrument's sensitivity). On the other hand the geographical position (Px) of each measurement falls within an area of ambiguity (depending on the accuracy of GPS). Those two areas are not identical. For that reason, an elementary geographical area of measurement (Point x) on the map (which will be produced by this simulation) can represent a greater geographical space where the SPL rates are "diffused" over a long radius. This is defined as a buffer zone around each measurement. Depending on the spatial density of measurements there might be overlaps of buffer zones. It is considered very important to examine these overlaps (spatial intersections) between "elementary measurement areas" and "diffused perception sound, SPL areas", in order to produce a reliable "georeferenced sound map" which it could be superimposed correctly on other traditional geographic features in purpose to study a "hidden" property of the landscape such as sound.

Inasmuch the measurements concern concrete spatial points, the rates for the intermediate positions, results through intercalation and so on. This process permits the redefinition of the model through a new adapted simulation in a timing changeable surface format.

The above process of producing a "georeferenced sound map" provides a new tool that could be used for the study of "soundscape", which concerns a specific environmental simulation/ analysis taking into account the registration of sound incidents on a map.

CONCLUSIONS

In comparison to other real-time modelling systems that use several fixed sensors (e.g. meteorological stations) or portable computers (e.g. mobile mapping), the proposed one needs only a single sensor that moves around. Regarding the part of data acquisition, it is not necessary to use a computer in the field, as the selected VHF radio manages sufficiently the measurements from the GPS and the sensor. Additionally, a commonly used system for visualization (such as AutoCAD) becomes an interface for "sound mapping", or furthermore an environment for the simulation of the "soundscape".

The modelling and simulation method in question provides a "sound map" (or "field map") capable for superimposition over other traditional geographic features, which permits to make evident a "hidden" property of the landscape : the sound. By this way is provided a new perspective of the landscape as sound enriches the analyst' s perception of space.

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