THE SONIFIED URBAN MASTERPLAN (SUM) TOOL : Sonification For Urban Planning And Design

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ABSTRACT

This paper describes the progress of an interdisciplinary project that explores the potential for sonification in urban planning and design. The project involves the translation of visual urban mapping techniques used in urban planning and design, into sound, through the development of the Sonified Urban Masterplan (SUM) tool. We will describe our sonification approach and outline the implementation of the SUM tool within the computer-aided composition environment PWGL. The tool will be applied to a selected urban data set to demonstrate its potential. The paper concludes with the advantages of such an approach in urban analysis, as well as introduces the possibility, within such CAC environments as PWGL and OpenMusic, to 'compose' urban plans and design using sound.

1. INTRODUCTION

Sonification, as a process of representing data through auditory means [1], has become increasingly utilised in scientific analysis since its introduction by Kramer in 1994. This is largely due to the efficiency of the ear in detecting temporal patterns, periodicity, and simultaneously following multiple parallel streams of auditory events [2]. In the social science of urbanism, concerned with numerous data flows, such a temporal representation technique can aid the understanding of their complex interrelationships.

The use of sonification in the urban realm has so far ranged from the analysis of various urban data sets [2], to the interactive sonification of geo-referenced data for navigation by the visually-impaired or for educational purposes [3]. Recently, the aesthetic potential of such urban data as a source for musical compositions has also become appreciated, as seen by the development of the COMPath tool [4].
However, the use of sonification as an alternative representative technique in the applied practice of urban planning and design, in the physical organization of such data, through built form, is still yet to be explored.

Thus this paper will explore the potential for sonification to not only aid representation for urban analysis, but to inform urban planning and design.

Currently, our work is realized inside PWGL [5], which is a widely-used Lisp-based visual CAC environment. This paper will present the computational model used in our approach. Moreover, it will discuss the development of a prototype of the Sonified Urban Masterplan (SUM) tool and present a language framework aimed at describing the sonification process.

2. BACKGROUND

Urban planning and design is an applied discipline, which must synthesise numerous datasets of information for design purposes. Occupied with space, its representation has traditionally relied on graphic means. However, while concerned with the organization and design of static objects in space, its effect on the urban system as a whole is inherently temporal.

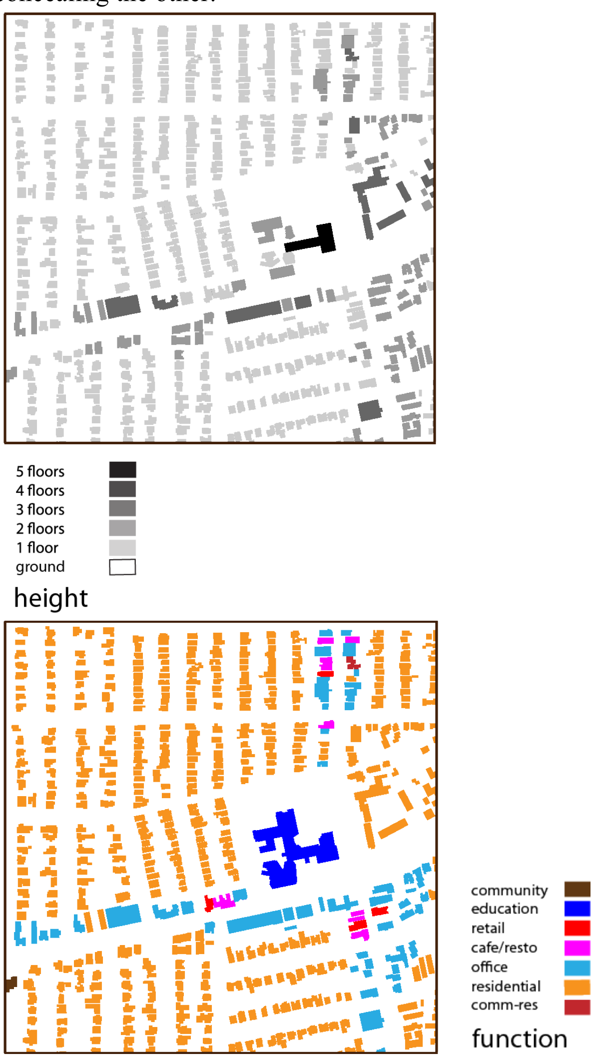
The static representation of dynamic urban systems can be seen to have contributed to the discrepancy between urban form, function and infrastructure in the post-industrial planned city. This can be seen in our following example of Perth, Australia, where the temporal needs of the pedestrian can be seen as largely neglected in relation to its car-scaled infrastructure.

The work of Sara Adhitya has been generously supported by the John Crampton Scholarship Trustees of Australia.
The work of Mika Kuuskankare has been generously supported by the Academy of Finland (SA137619).

Thus with urban planning being a temporal field, yet based traditionally on a static, visual representation technique, sonification can only help urban planners better identify and cater for their temporal demands.

3. ISSUES OF REPRESENTATION

The process of urban planning and design is reliant on its representation technique, usually involving the development of an overall graphic 'urban masterplan' from the synthesis of numerous other urban datasets. However, the representation of all these data attributes on the one map is constrained for obvious legibility reasons. Thus the data is often separated into individual maps. For example, Figure 1 shows two different data attributes of the same structural element: building height and building function; which would otherwise be difficult to represent on the one map without one map concealing the other.



Figures 1: 2 different attributes of the same structural element: building height and building function

However, for urban planners interested in analyzing the relationships between these multiple datasets, this separation due to visualization does not aid their synthesis.

Thus we propose the ability of sonification, through its own multiple attributes, to aid the simultaneous representation of multiple data attributes.

4. THE SUM TOOL

The Sonified Urban Masterplan (SUM) tool (see Figure 3) aims to synthesise the data of individual maps to be contained in one 'sonified mapset'.

The user organises their data as separate maps according to their attributes of interest. These maps are raster images saved at 72 PPI, allowing each map to be read as a 1:1 matrix of pixels. RGB colour format is utilized and with each data attribute allocated a colour-value, the standard colour-coding conventions in urban planning can be adhered to. With transparency retained, an empty (transparent) pixel indicates the absence of data, while a filled pixel represents its presence. The layering of raster images produces a matrix of data, as illustrated in Figure 2.

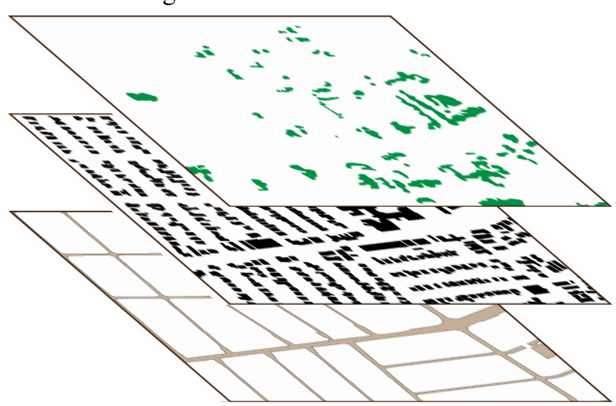


Figure 2: the layers of data form a matrix

The maps can be created in a graphic program such as Adobe Illustrator, commonly used in architectural and urban planning representation. Being vector-based, it allows the importation of .dxf files, a vector format in which cadastral data is usually available or exportable from standard GIS or CAD software. Within the program it allows its manipulation, and generation, to form the desired layers and their coding using colours.

Once generated, this mapset can then be loaded into the SUM tool (see Figure 3), where the sonification process

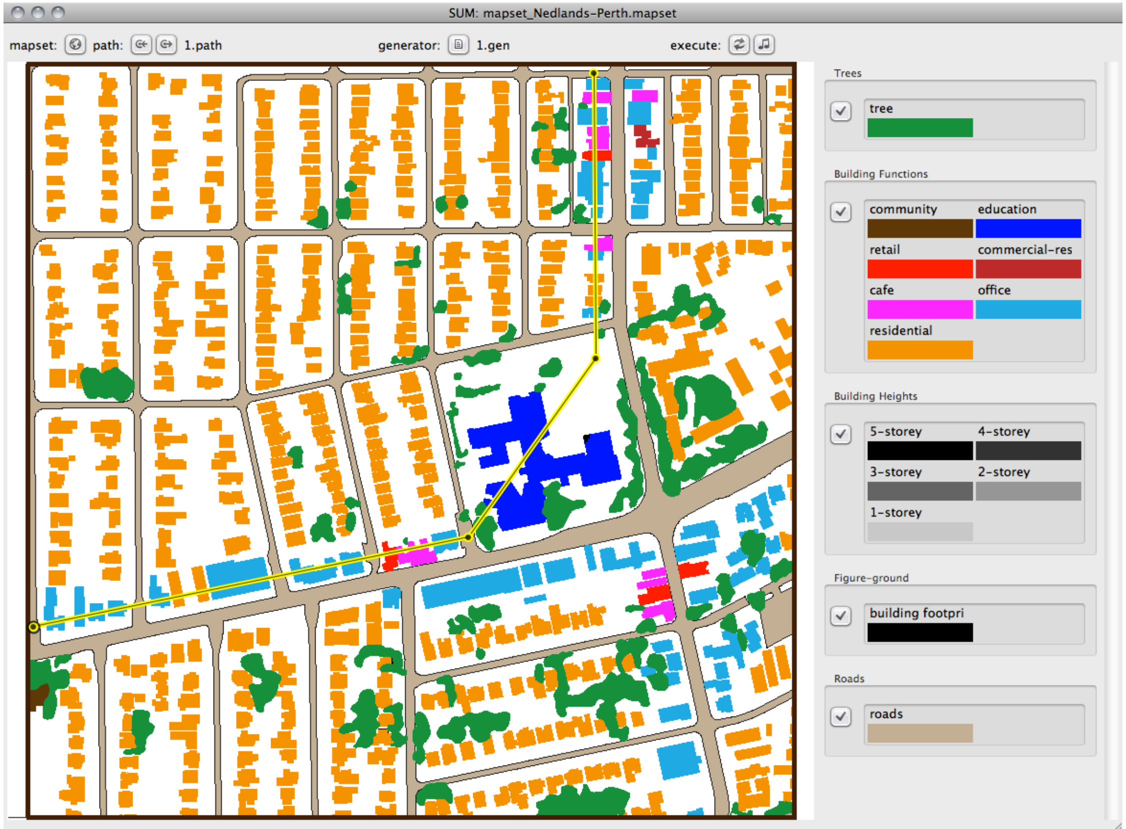


Figure 3: SUM tool user-interface displaying the current mapset (left), and the dataset legends (right).

can be defined. In our example, a 800m by 800m mapset of the suburb of Nedlands in Perth, Australia is displayed. This mapset is limited to include 3 urban structural elements (building, roads, and trees), of which one (building) has 2 sets of attributes (height and function).

5. DATA RETRIEVAL

In the SUM tool, the mapset becomes a type of open 'musical score', 'played' by the user drawing a polyline on the mapset over the areas of interest. This indicates which elements are to be played over time. To break the vector polyline into discrete sampling points the path is rasterized according to Bresenham's line algorithm. In our application, the order of the points is of importance as it determines the direction of the path along which the time progresses. Thus for a line extending upwards and to the left, the pixels would be sampled in the order shown in Figure 4. Each raster map image is then sampled pixel by pixel to retrieve the data of interest per each sample-point along the path. The playback speed is specified in terms of the duration of one pixel unit (termed 'unit-duration') in seconds.

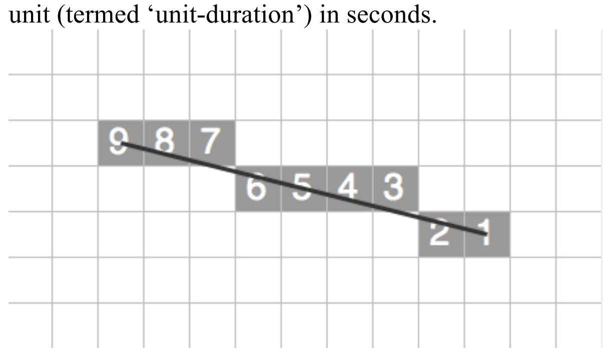


Figure 4: Diagram of Bresenham's line algorithm, with sampling order

6. SONIFICATION APPROACH

The sonification technique used is parameter mapping, in which various aspects of the data are directly converted in terms of the various attributes of the acoustic signal: pitch; volume; timbre; duration; and their overall temporal organization expressed as rhythm.

At this point, it is important to be able to experiment with different data-sources (mapsets), paths, and sonification processes. To this end, we have developed a language framework called SUMDL (sonified urban masterplan definition language), the native format of the SUM tool. Using the SUMDL, it is possible to describe the whole sonification process beginning from the dataset to the final musical score.

In the next sections we introduce the SUMDL language framework and give working examples regarding its usage.

6.1. The SUM Description Language

The SUMDL language framework consists of 3 domain specific languages: (a) a mapset definition language; (b) a path definition language; and (b) a sonification specification language. A set of packrat parsers [6] were developed allowing us to generate the various SUM tool objects out of SUMDL description files. The parsers are implemented using a Lisp-based packrat parser called 'esrap' [7] by Nikodemus Siivola. A packrat parser lends itself well for designing extensible and dynamic languages. The main idea behind the proposed languages is to allow users without extensive programming background to easily experiment with the system.

8.1 The Mapset Description Language (.mapset)

An example of a potential mapset description is given in Listing 1. Here, we define a mapset called "Nedlands, Perth" consisting of two maps. The 'legends' section is of primary interest in terms of the sonification process. It is used to enumerate the attributes of the given map. In this example, both maps have only one attribute. For example, the attribute provided by the first map is called "tree" and it is given an attribute called color with value ':green'. This information is used to convert the data represented by the map's raster image (given with the keyword ':image') into a list of numeric values. These values, in turn, are used in the sonification phase to transform the data into sound.

```
:mapset
 :title "Nedlands, Perth"
   :maps
     :map
       :order 2
       :title "Trees"
       :image "trees.png"
       :legends
         :legend
           :data-name "tree"
           :data-description :green
     :map
       :order 1
       :title "Figure-ground"
       :image "figureground.png"
       :legends
         :legend
           :data-name "building footprint"
           :data-description :black
```

Listing 1. A mapset defined with the help of the Mapset Description Language.

8.2 The Sonification Description Language (.gen)

The Sonification Description Language allows us to describe the mapping between the mapset and the resulting sound. The format (see Listing 2) consists of a score-generator description that can contain an arbitrary number of part-generators. Each part-generator defines the data-source, and the mapping between the resulting sound and the properties derived form the data- source. As an example, the following general mapping approach (Table 1) could be applied to each structural element. Each structural element could be expressed by a different instrument, allowing different functions to be acoustically identifiable by their differing timbres.

Table 1: Parameter-mapping of urban structure to sound

Structural Attribute	**Sound Attribute**
Height	Pitch
Function	Timbre
Density	Volume
Distance	Duration

In our example, we have mapped the building height (number of stories) to a chromatic scale above middle C, taken as the base note at ground level (see the part marked as pitch). Furthermore, the unit-duration is set at 0.06 to reflect the speed of the predominant transport infrastructure, the car at a speed of 60km/h.

```
:score-generator
  :part-generator
    :pitch
      :data-source "Building Heights"
      :post-process #'(lambda (h) (+ h 60))
    :volume
      :data-source ()
      :default 60
    :unit-duration
      :data-source ()
      :default 0.06
    :channel
      :data-source "Building Functions"
      :post-process #'(lambda (i) (case i
                             (0 "Tubular_Bells")
                             (1 "Celesta")
```

```
(2 "Glockenspiel")
(3 "Glockenspiel")
(4 "Vibraphone")
(5 "Marimba")
(6 "Xylophone")
(7 "Reverse_cymbal")))
```

Listing 2. The sonification process is described using the Sonification Description Language.

7. RESULTS

While working with this limited data sample, interesting results have been produced. These will be presented as audio files as part of the poster presentation, along with a demonstration of the SUM tool prototype.

Apart from the obvious temporal contrast between the experience of the urban morphology at the speed of the car, compared to that of the pedestrian, it is also possible to acoustically identify patterns of urban structure with their visual counterparts. It is possible to compare and contrast the difference between one zoned area and another, for example a residential street of repetitive 1-storey houses, compared to a commercial street of more varied function and form.

These preliminary results highlight the importance of the relationship between the scale of the built form and the speed of the transport infrastructure provided, in the creation of urban experience.

8. LIMITATIONS AND OPPORTUNITIES

Both a limitation and opportunity of this prototype tool is its flexibility. It is up to the informed user to first a) understand what he or she wants to analyse from the dataset, and then b) organise it into layers and sublayers, which will later allow c) the generation of the different permutations of interest. This means that, depending on the complexity of the data input, the possibilities are limitless.

The use of industry-standard software to produce these maps – AutoCAD, ArcInfo, and Adobe Illustrator – aims to promote its implementation by design professionals.

9. CONCLUSIONS

As the representation of those physical elements which construct the experience of an abstract body travelling along a selected path at a chosen speed, the SUM tool at this stage is essentially a sonified representation of urban morphology. While this method of sonification does not claim to express urban 'experience' in the perceptive sense, it attempts to represent those physical elements which construct it. However, these sonification results may begin to inform 'urban soundscape compositions' for musical purposes.

Of future interest is the sonification of whole areas, contained within polygons. This would allow the sonification of the overall urban 'texture' of a built environment.

The long-term intention of the SUM tool created within a CAC environment such as PWGL or OpenMusic, is to incorporate the use of sound in the urban planning and design process.

10. ACKNOWLEDGMENT

We would like to thank IRCAM, and in particular l'Équipe Représentations Musicales, for hosting us during this collaboration.

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