New Trends in Non-visual Interaction - Sonification of Maps

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Abstract. An inexpensive sonification system of maps and charts for visually impaired is described. A digitiser (tablet) is used as system's input device, which helps to investigate the map. The maps are presented using xml technology – mainly svg language tags. Then the maps from svg are converted to RGB bitmap. A system software is based on Microsoft .NET technology. Free Microsoft development systems as Visual C# 2008 Express Edition and Direct Sound are used to implement sonification system.

Keywords: Blind, sonification, map, svg language.

1 Introduction

With the increasing usage of multimedia systems, there is a real need for developing tools able to offer aids for visually impaired or blind people in accessing graphical information. This technological development opened new prospects in the realization of man-machine interfaces for blind users. Many efforts have been devoted to the development of sensory substitution systems that may help visually impaired and blind users in accessing visual information such as text, graphics, or images.

Creating, manipulating, accessing, and sharing information such as pictures, maps, charts and other visualisations as well as mathematical data and tables are fundamental skills needed for life. Visualisation is commonly used within almost every scientific field. For teaching blind children or students other information presentation ways must be found, which replace visual information. Solution is to transform visual information to stimulus which could be perceived by others human sensor systems, which are functioning normally. We selected approach that transformation to auditive signals must be preferred.

One of the first approaches to use sonification signals in human computer interaction is called earcons [1]. Sounds used for earcons should be constructed in such a way that they are easy to remember, understand and recognise. It can be a digitised sound, a sound created by a synthesiser, a single note, a motive, or even a single pitch.

A method for line graph sonification invented in the mid 1980s was called SoundGraphs [2]. Movement along the x-axis in time causes notes of different pitches to be played, where the frequency of each note is determined by the value of the graph at that time. It was established by experiments with fourteen subjects that after a

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small amount of training, test subjects were able to identify the overall qualities of the data, such as linearity, monotonicity, and symmetry. The flexibility, speed, cost-effectiveness, and greater measure of independence provided for the blind or sight-impaired using SoundGraphs was demonstrated.

In the late 1980s a system called Soundtrack was developed [3]. It is a word processor for visually impaired people. The interface consists of auditory objects. An auditory object is defined by its spatial location, a name, an action, and a tone.

Invention of haptic devices leaded to design of multi-modal interfaces to access graphical information. This technique was used in the GUIB system in which graphics were communicated using sound and text using synthesised voice or Braille [4].

Some of them are based on transformation of visual information to auditive signal. These approaches assume a sufficient knowledge of both visual and auditory systems. At present time, we can consider that the various solutions suggested for text access are acceptable. However, the information presented in the form of graphics or images presents a major obstacle in the daily life of blind users.

2 Method

Our aim was to develop widely available graphical information presentation system for blind user[5]. We tried to use most common and cheapest hardware and open source or free software components.

Nowadays vector graphics format is widely used to store digitized maps. Often rich interactive maps are published in web using SVG file format which is an XML markup language for describing two-dimensional vector graphics. It is an open standard created by the World Wide Web Consortium. The available fill and stroke options, symbols and markers enable higher quality map graphics.

As a XML based language, SVG supports foreign namespaces. It is possible to define new elements or add new attributes. Elements and attributes in a foreign namespace have a prefix and a colon before the element or attribute name. Elements and attributes in foreign namespaces that the SVG viewer does not know, are ignored. However, they can be read and written by script. Foreign namespaces are used to introduce new elements (e.g. GUI elements, scalebars) and for the attachment of non-graphical attributes to SVG graphic elements.

Most suitable software for browsing interactive SVG maps some years ago was plugin Adobe SVG Viewer, available for all major platforms and browsers (Linux, MacOSX, Solaris, Windows) which earlier could be downloaded free from the Adobe SVG homepage.

Mapping represents a perfect application of SVG because maps are, by nature, vector layered representations of the earth. The SVG grammar allows the same layering concepts that are so crucial to Geographic Information Systems (GIS). Since maps are graphics that depict our environment, there is a great need for maps to be informative and interactive. SVG provides this interaction with very high quality output capability, directly on the web. Because of the complexity of geographic data (projection, coordinate systems, complex objects, etc.), the current SVG specification does not contain all the particularities of a GIS particularities. However, the current specifica-

tion is sufficient to help the mapping community produce open source interactive maps in SVG format.

Text field with information about the map is information for presentation to user by speech synthesis. Other elements represent regions of maps. Actually, region is graphical tag of SVG, which describes contour of region. This tag has attributes related to sound, text and similar. Sound attribute allows to indicate sound file, which is played when cursor is over region. Text attribute is devoted to information about selected region.

In our application we need devices which give absolute coordinates. There are two choices: tablet and touchscreen. For graphical input on desktop or laptop computer we selected digitiser (tablet) as cheaper and more accurate device. PC computer have sound system and installed Microsoft Windows XP (Service Pack2) operation system. Created sonification software without executable file has resources (collections of WAV and XML format files) and configuration file.

Software must implement these actions:

- loading default system configuration;
- selection of XML file;
- parsing of XML file;
- handling of mouse move events or menu options.

Moving of pen on tablet invokes mouse movement event in computer OS. Mouse events must initiate the generation of non speech sound. Mouse coordinates are defined and by them it is determined, over which region the mouse is present. If the mouse is on the same region as previously, now changes are done to played wav file. If the mouse goes to the new region, correspondingly, the old sound file is stopped and new file is started to play. Additionally, the distance of cursor point to the region boundary is measured to give alert signal if cursor is approaching the boundary of region.

The algorithm for determination of distance is next. The initial direction angle and the step for angle increase are selected. By default angle is equal to 0 degrees and step is equal to 5 degrees. We go from cursor point by the given angle while we reach boundary. Boundary is reached when pixel colour changes. Then we calculate Euclidean distance from cursor point to point on the boundary. The obtained value is stored in the array. Next direction is selected by adding angle step to current direction angle. And again point on boundary and distances is found (Figure 1)). From the array of distances, which is plotted in Figure 2, minimal distance is defined.

A warning sound signal about boundary of two regions is issued, when pen of digitiser is close to the boundary. Because it is easy to jump through boundary without stop on it the signal is started to generate at some distance from boundary when the pen is approaching to it. Also it is necessary to indicate when the pen goes toward to boundary or is departing from boundary. So volume of sound is selected according to the distance from exact intersection of two regions. If the pen moves parallel to the boundary then the volume remains at constant level. When the pen is points on boundary detection in all directions approaching to boundary the volume of warning sound is increased. The maximal volume is reached on exact boundary. The volume is decreased when pen crosses the boundary and recedes from it.

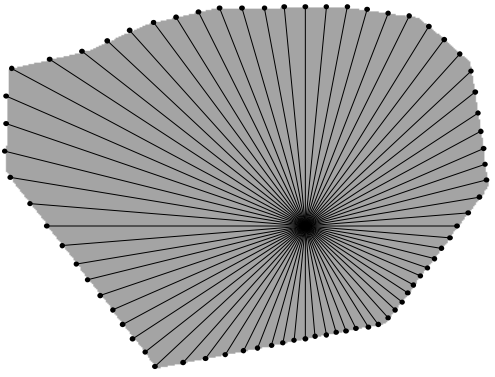

Fig. 1. Map with contour of Finland and example of contour description (points on boundary detection in all directions)

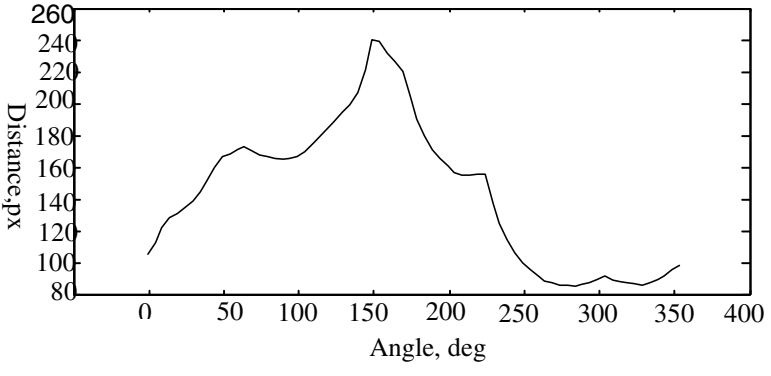

Fig. 2. Map with contour of Finland and example of contour description (plot of distances between cursor point and boundary points)

3 Implementation

In this section we will discuss implementation issues of the sonification system. For coding we selected C# language. We used the free Microsoft Visual C# 2008 Express Edition. The Windows application is based on ***System.Windows.Forms*** assembly.

The developed software must be very stable because it will be impossible for a disabled to solve a software crash and respond to unpredicted dialog boxes. Best guarantee for stability should be found in widely used technologies. In recent years the .NET Framework by Microsoft has brought the ability to write much more robust and secure code on the Windows platform.

.NET Framework promises good options for interoperability. It is easy to combine code written in different .NET languages because all code is first translated into CIL (Common Intermediate Language). CTS (Common Type System) also exists and ensures compatibility of parameter types in functions calls. It is simpler to invoke

methods on COM objects. There are also some choices for cross-machine communication between managed modules.

The parsing of SVG document was implemented using XLINQ library functions, other called as LINQ to XML library. LINQ defines a set of general purpose standard query operators that allow traversal, filter, and projection operations to be expressed in any .NET-based programming language. XLINQ provides both DOM and XQuery/XPath like functionality in a consistent programming experience across the different LINQ-enabled data access technologies.

We used object-oriented programming technology. XLINQ allows parse data from XML file directly to classes of graphical objects.

Graphical rendering was implemented with Windows GDI+ functions. PictureBox control allows draw stable pictures. Included bitmap in it allows organise navigation plane.

For speech synthesis we used Speech library from NET. Framework version 3.0. It allows not only synthesize English speech but also some effects as emphasis of words or speech rate changes by 5 levels.

Only one software component was used outside .NET Framework. It was DirectSound library from Microsoft DirectX version 9c. Attractive features of DirectSound are advanced sound playing control: some files in the same time with independent parameters control.

4 Discussion

The differences of visual and auditory systems are pointed by Brewster [6]. Our visual system gives us detailed information about a small area of focus whereas our auditory system provides general information from all around, alerting us to things outside. Visual system has a good spatial resolution, while auditory system has preference in time resolution. So it is impossible to convey the same information by these two information channels.

In the sonification report [7] it is stated that progress in sonification will require specific research directed at developing predictive design principles. There is also indicated about the need of research by interdisciplinary teams with funding that is intended to advance the field of sonification directly, rather than relying on progress through a related but peripheral agenda.

Analysis shows that there many different sonification efforts including solutions for visually impaired but they are more as project results and are not widely available. The described sonification system can be easily implemented and easily integrated to bigger projects. The improvements mostly can concern selection of sounds.

5 Conclusions

XML format files were successfully used for preparing information for sonification. The developed model of sonification was successfully implemented using free software development tools: Microsoft Visual C# 2008 Express Edition and Microsoft DirectSound library.

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