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WhatsOnWeb: A Sonificated Search Engine for Blind People

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Summary

In this work, we present the sonification procedure of a visual Web search engine called WhatsOnWeb (WoW) and its usability evaluation. The WoW search engine is based on graphic visualisation algorithms conveying datasets by semantic correlations and clusters through graph-drawing methods. WoW has been developed combining different visual and auditory features in three sonificated layouts that transmit spatial information through acoustic non-verbal events. WoW usability has been evaluated for both visual and sonificated versions with blind and sighted users. Since results show no differences in usability, we conclude that the sonification methodology makes visual content accessible, usable and, therefore, equally learnable for both blind and sighted people.

Introduction

The first version of the web search engine, WhatsOnWeb (WoW) (DI GIACOMO *et al.*, 2007; DI GIACOMO *et al.*, 2008), proposed to overcome the limitation of flat top-down spatial representation used by the most common search engines, where the order of results does not take into account the quality of the information conveyed (FEDERICI *et al.*, 2008, 2010). In WoW, the indexed Web datasets are represented through graph-drawing methods based on sophisticated graphic visualisation algorithms through the use of semantic correlations and clusters. As with most of the common search engines, WoW retrieves datasets by using the *PageRank* algorithm (BRIN and PAGE, 1998) and represents them in a single page through a semantic network of concepts and sub-concepts constituting an interactive spatial map. In this way, as graphical spatial representation facilitates the information processing by semantic categorization (ANDERSON, 1993), WoW overcomes the gap between the quantitative order and qualitative level of Web information that arises in most of the flat top-down search engines. As it meets, supports and enhances the cognitive processes involved in the interaction between user and interface, we define the geometrical spatial representation of WoW as a *psychotechnology* which emulates, extends, amplifies or modifies the sensory-motor, psychological or cognitive functions of the mind (FEDERICI *et al.*, 2011; FEDERICI and SCHERER, 2012; MIESENBERGER, CORRADI, and MELE, 2012).

In this work, we present a sonification procedure applied to WoW's visual interface, i.e., an alternative way to transmit spatial data through non-visual means. We followed a user centred design perspective (BORSCI *et al.*, 2013) to transform "data relations into perceived relations in an acoustic signal for the purposes of facilitating communication or interpretation" (KRAMER *et al.*, 1997, p. 3). We used the sonification transformation model Action by Design Component (ADC; ZHAO, SHNEIDERMAN, and PLAISANT, 2007), which transforms the visuo-spatial data output into a corresponding audio-spatial output. We evaluated the differences between totally blind and sighted users' experiences while they were respectively interacting with the corresponding WoW sonificated or visual version of the search engine (MELE *et al.*, 2012).

Materials & Method

Many studies highlight that the motion ability of blind users involved in spatial exploration guided only by acoustic cues is functionally equivalent to the visually guided one (OLIVETTI BELARDINELLI *et al.*, 2009). This study aims to introduce a new way to convey web-indexed information by using a sonification methodology. The user experience evaluation of both visual and sonificated WoW versions shows no differences between blind and sighted people.

Participants. 8 participants (4 males; 4 blind users; mean age 28.2; standard deviation 5.9) took part to the experiment. Blind subjects were selected in accordance with a diagnosis of either early or inherited blindness.

Materials. The visual version of WoW is composed by a customisable layout. Users can choose between three graphic configurations: radial (Figure 1.A), layered (Figure 1.B) and spiral TreeMap (Figure 1.C) whose effectiveness and efficiency were previously evaluated (DI GIACOMO *et al.*, 2007; DI GIACOMO *et al.*, 2008). The graphic structure of WoW is organised by semantic correlations among the indexed abstract information. Navigation uses cluster nodes as semantic sets of results and leaf nodes representing a website or a document. Both cluster and leaf nodes can be expanded or collapsed and, together, they form a single page representation of all the indexed searched information (Figure 1). Nodes are related to each other by edges representing their semantic relations.

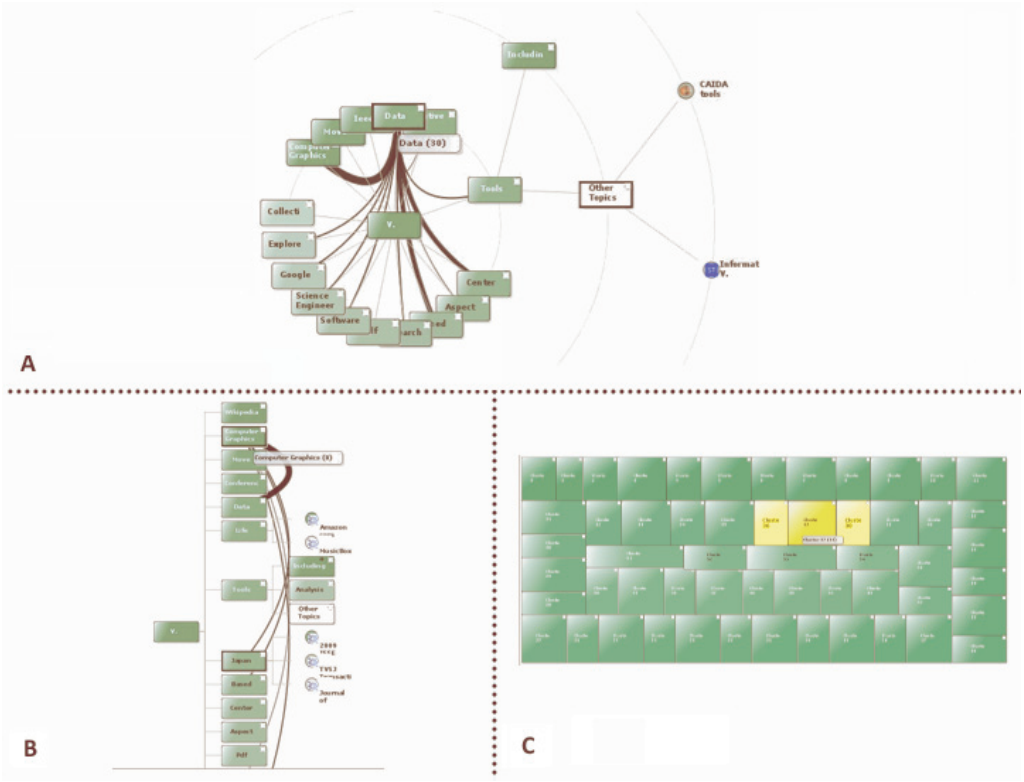

Figure 1. WhatsOnWeb layouts: (A) radial; (B) layered; (C) spiral TreeMap

Design and procedure

1) Sonification. The sonification model Action by Design Component (ADC) provides users with a dynamic interaction acoustic interface (ZHAO *et al.*, 2007). We used the ADC model to design and test a sonification layout of the accessible visual version of WoW presented in 2009 (MELE *et al.*, 2009; RUGO *et al.*, 2009) to transmit the spatial and semantic information of graphical features and their combinations in an acoustic non-verbal way. We applied the sonification process by combining visual and non-verbal acoustic features in a univocal way. Table 1 shows three different sonification layouts developed by using different combinations of tone, pitch, volume, blinking and grid reference with the z axis representing the spatial position of the graphic objects of WoW, the web ranking of each node, the level of navigation and the type of node. We obtained three different types of sonification layouts *PanAndPitch*, *VolumeAndPitch* and *BlinkAndPitch*.

Table 1: The three sonification layout prototypes of WhatsOnWeb

	x Axis	y Axis	Ranking	Level
PanAndPitch	Panning	Pitch	Volume	Timbre
VolumeAndPitch	Volume	Pitch	Blinking	Timbre
BlinkAndPitch	Blinking	Pitch	Volume	Timbre

The three layouts can be navigated via the following steps: (i) after users press enter to execute their query, a first global overview is displayed: this function corresponds to a temporisation technique (SAUE, 2000), which transforms information from a non-temporal to a temporal (auditory) domain; ii) the navigation through the graph of results is then translated into complex tones corresponding to the paraverbal information of clusters, leaf nodes and their semantic relations (edges); iii) users orient their position throughout the interface thanks to a reiterable feedback function providing the opening overall preview and a position signal that describes the current position among the navigation steps; iv) verbal feedback voiced by an integrated synthesiser (or a customised screen reader software) provides textual information by which users can identify and memorise data.

2) Evaluation. We conducted two kinds of user evaluations: (i) a heuristic evaluation and (ii) a user experience evaluation (UX). (i) First, a heuristic evaluation conducted by three experts tested the usability of each a sonification layout by using a readjustment of Nielsen's heuristics (1994) to a simulated user scenario. The results were applied to design a single layout composed by the best combination between the acoustic and visual features, the *PanAndPitchBlinking sonification* layout (Table 2). The *PanAndPitchBlinking* sonification layout conveys spatial information through the z-axis by means of the panning technique to represent the position on the x-axis and the pitch feature to represent the position on the y-axis. Moreover, sound blinking represents the rank order of each node.

Table 2: The PanAndPitchBlinking sonification layout of WhatsOnWeb

	x Axis	y Axis	Ranking	Level
PanAndPitchBlinkin	Panning	Pitch	Blinking	Timbre

ii) The UX of the three Radial, Layered and Spiral TreeMap visual layouts and the *PanAndPitchBlinking* sonificated layout were evaluated with blind and sighted users. The UX evaluation has been evaluated by using the Partial Concurrent Thinking Aloud (PCTA) protocol (FEDERICI, BORSCI, and MELE, 2010; FEDERICI, BORSCI, and STAMERRA, 2010) and the System Usability Scale (SUS) questionnaire (BORSCI, FEDERICI, and LAURIOLA, 2009; BROOKE, 1996). After an exploration of the layout lasting at least 3 minutes, users were asked to conduct an exhaustive WoW search by using the keyboard.

Results

Nineteen problems, 9 related to visual performance and 10 problems related to auditory performance were found. No significant differences between blind and sighted users and between visual and auditory layouts (Layered layout, $F(1,6)=4.524$; $p>.05$; Spiral TreeMap layout, $F(1,6)=0.097$; $p>.05$) were found, except for the Radial layout ($F(1,6)=13.690$; $p<0.05$). The analysis of the SUS scores shows no significant differences ($F(1,6)=0.2729$; $p>.05$) between blind and sighted subjects. A similar level of efficacy, efficiency and satisfaction between blind and sighted groups and between the visual and sonificated information presentation, highlights a functional homogeneity between sighted and blind UX users of WoW.

Conclusion

The way in which search engines represent and transmit information may hinder people with disabilities to access and use web-indexed information (FEDERICI *et al.*, 2008, 2010). This is particularly true for people with visual disabilities, individuals who may face high accessibility problems in consulting web information content (JAY *et al.*, 2007) because of the flat top-down spatial ways in which search engines are commonly organised. However, since we know that the cognitive representation of spatial information is independent of the way in which sensory data are conveyed, other non-visuocentric ways to convey web information can be used. For this reason, designing alternative sensory interfaces to transmit web content is a promising challenge to reach the goal of universal access to web information (STEPHANIDIS, 2001).

In this work, we presented a sonificated version of WhatsOnWeb, a web search engine representing the web-indexed information in a single page through a semantic network of concepts and sub-concepts constituting

an interactive spatial map. We described the sonification process of the visual display of WoW and the analysis of the blind and sighted users experience while they respectively interacted with the sonificated and the visual display of WoW. As no qualitative or quantitative differences between groups' performances were found, data confirm the functional correspondence between visual and auditory sensory information in spatial representation (OLIVETTI BELARDINELLI *et al.*, 2009). Therefore, this work highlights that organisation through semantic categorisations facilitates the cognitive information processes that organises human knowledge (ANDERSON, 1993). As it supports and enhances the cognitive process involved in the interaction, independently from the sensory way in which information is transmitted, WoW should be considered a psychotechnology emulating, extending, amplifying or modifying the sensory-motor, psychological or cognitive functions of the mind (FEDERICI *et al.*, 2012).

References

ANDERSON, John Robert, The Architecture of Cognition, Cambridge, MA, Harvard University Press, 1993.

BORSCI, Simone, FEDERICI, Stefano, and LAURIOLA, Marco, On the Dimensionality of the System Usability Scale (SUS): A Test of Alternative Measurement Models, Cogn Process, 3, 193-197, 2009. doi:10.1007/s10339-009-0268-9

BORSCI, Simone, KUROSU, Masaaki, FEDERICI, Stefano, and MELE, Maria Laura, Computer Systems Experiences of Users with and without Disabilities: An Evaluation Guide for Professionals, Boca Raton, FL, CRC Press, 2013.

BRIN, Sergey and PAGE, Larry, The Anatomy of a Large-Scale Hypertextual Web Search Engine, 7th International World-Wide Web Conference: WWW '98, Brisbane, AU, pp. 1-20, 1998.

BROOKE, John, SUS: A "quick and dirty" usability scale, in, JORDAN, Patrick W., THOMAS, Bruce, WEERDMEESTER, Bernard A., and MCCLELLAND, Ian L. (Eds.), Usability evaluation in industry, London, UK, Taylor & Francis, pp. 189-194, 1996.

DI GIACOMO, Emilio, DIDIMO, Walter, GRILLI, Luca, and LIOTTA, Giuseppe, Graph Visualization Techniques for Web Clustering Engines, IEEE Trans Vis Comput Graph, 2, 294-304, 2007. doi:10.1109/TVCG.2007.40

DI GIACOMO, Emilio, DIDIMO, Walter, GRILLI, Luca, LIOTTA, Giuseppe, and PALLADINO, Pietro, WhatsOnWeb+: An Enhanced Visual Search Clustering Engine, IEEE Pacific Visualization Symposium: PacificVIS '08, Kyoto, Japan, pp. 167-174, 2008.

FEDERICI, Stefano, BORSCI, Simone, and MELE, Maria Laura, Usability evaluation with screen reader users: A video presentation of the PCTA's experimental setting and rules, Cogn Process, 3, 285-288, 2010. doi:10.1007/s10339-010-0365-9

FEDERICI, Stefano, BORSCI, Simone, MELE, Maria Laura, and STAMERRA, Gianluca, Global Rank: tra popolarità e qualità dei siti Web, Psicotech, 1, 7-23, 2008. doi:10.1400/113633

FEDERICI, Stefano, BORSCI, Simone, MELE, Maria Laura, and STAMERRA, Gianluca, Web Popularity: An Illusory Perception of a Qualitative Order in Information, Univ Access Inf Soc, 4, 375-386, 2010. doi:10.1007/s10209-009-0179-7

FEDERICI, Stefano, BORSCI, Simone, and STAMERRA, Gianluca, Web usability evaluation with screen reader users: Implementation of the Partial Concurrent Thinking Aloud technique, Cogn Process, 3, 263-272, 2010. doi:10.1007/s10339-009-0347-y

FEDERICI, Stefano, CORRADI, Fabrizio, MELE, Maria Laura, and MIESENBERGER, Klaus, From cognitive ergonomist to psychotechnologist: A new professional profile in a multidisciplinary team in a centre for technical aids, in, GELDERBLOM, Gert Jan, SOEDE, Mathijs, ADRIAENS, Leon, and MIESENBERGER, Klaus (Eds.), Everyday Technology for Independence and Care: AAATE 2011, Amsterdam, NL, IOS Press, pp. 1178-1184, 2011.

FEDERICI, Stefano and SCHERER, Marcia J. (Eds.), Assistive Technology Assessment Handbook, Boca Raton, FL, CRC Press, 2012.

JAY, Caroline , STEVENS, Robert , GLENCROSS, Mashhuda , CHALMERS, Alan, and YANG, Cathy How people use presentation to search for a link: Expanding the understanding of accessibility on the Web, Univ Access Inf Soc, 3, 307-320, 2007. doi:10.1007/s10209-007-0089-5

KRAMER, Gregory, WALKER, Bruce, BONEBRIGHT, Terri, COOK, Perry, FLOWERS, John, MINER, Nadine, and NEUHOFF, John, Sonification Report: Status of the Field and Research Agenda, in, Santa Fe, NM, National Science Foundation by members of the International Community for Auditory Display, 1997.

MELE, Maria Laura, BORSCI, Simone, RUGO, Alessio, FEDERICI, Stefano, LIOTTA, Giuseppe, TROTTA, Francesco, and DI GIACOMO, Emilio, An Accessible Web Searching: An On-going Research Project, in, EMILIANI, Pier Luigi, BURZAGLI, Laura, COMO, Andrea, GABBANINI, Francesco, and SALMINEN,

Anna-Liisa (Eds.), Assistive Technology from Adapted Equipment to Inclusive Environments: AAATE 2009, Amsterdam, NL, IOS Press, pp. 854, 2009.

MELE, Maria Laura, FEDERICI, Stefano, BORSCI, Simone, and LIOTTA, Giuseppe, User Experience Evaluation of WhatsOnWeb: A Sonificated Visual Web Search Clustering Engine, in, Int J Comput Inform Syst Ind Manage Appl, US, Dynamic Publishers, pp. 352-357, 2012.

MIESENBERGER, Klaus, CORRADI, Fabrizio, and MELE, Maria Laura, The Psychotechnologist: A new profession in the Assistive Technology Assessment, in, FEDERICI, Stefano and SCHERER, Marcia J. (Eds.), Assistive Technology Assessment Handbook, Boca Raton, FL, CRC Press, pp. 179-200, 2012.

NIELSEN, Jakob, Heuristic evaluation, in, NIELSEN, Jakob and MACK, Robert L. (Eds.), Usability Inspection Methods, New York, NY, John Wiley & Sons, 1994.

OLIVETTI BELARDINELLI, Marta, FEDERICI, Stefano, DELOGU, Franco, and PALMIERO, Massimiliano, Sonification of Spatial Information: Audio-tactile Exploration Strategies by Normal and Blind Subjects, in, STEPHANIDIS, Constantine (Ed.), Universal Access in HCI, Part II, HCII 2009, LNCS 5615, Berlin, DE, Springer, pp. 557-563, 2009.

RUGO, Alessio, MELE, Maria Laura, LIOTTA, Giuseppe, TROTTA, Francesco, DI GIACOMO, Emilio, BORSCI, Simone, and FEDERICI, Stefano, A Visual Sonificated Web Search Clustering Engine, Cogn Process, Suppl 2, S286-289, 2009. doi:10.1007/s10339-009-0317-4

SAUE, Sigurd, A model for interaction in exploratory sonification displays, International Conference on Auditory Display (ICAD), International Community for Auditory Display, Atlanta, GA, US, pp., 2000.

STEPHANIDIS, Constantine, User Interfaces for All: New Perspectives into Human-Computer Interaction, in, STEPHANIDIS, Constantine (Ed.), User Interfaces for All: Concepts, Methods, and Tools, Mahwah, NJ, Lawrence Erlbaum Associates, pp. 3-17, 2001.

ZHAO, Haixia, SHNEIDERMAN, Ben, and PLAISANT, Catherine, Listening to Choropleth Maps: Interactive Sonification of Geo-referenced Data for Users with Vision Impairment, in, LAZAR, Jonathan (Ed.), Universal Usability: Designing Computer Interfaces for Diverse User Populations, West Sussex, UK, Wiley and Sons, pp. 141-174, 2007.