

# A Haptic Rendering Engine of Web Pages for Blind Users

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## ABSTRACT

To overcome the shortcomings posed by audio rendering of web pages for blind users, this paper implements an interaction technique where web pages are parsed so as to automatically generate a virtual reality scene that is augmented with a haptic feedback. All elements of a web page are transformed into a corresponding “hapget” (haptically-enhanced widget), a three dimensional widget exhibiting a behavior that is consistent with their web counterpart and having haptic extension governed by usability guidelines for haptic interaction. A set of implemented hapgets is described and used in some examples. All hapgets introduced an extension to UsiXML, a XML-compliant User Interface Description Language that fosters model-driven engineering of user interfaces. In this way, it possible to render any UsiXML-compatible user interface thanks to the interaction technique described, and not only web pages.

## Categories and Subject Descriptors

D.2.2 [Software Engineering]: Design Tools and Techniques – *User interfaces*. H.5.2 [Information Interfaces and Presentation]: User Interfaces – *Graphical user interfaces*. I.3.6 [Computer Graphics]: Methodology and Techniques – *Interaction techniques*

## General Terms

Design, Human Factors, Languages.

## Keywords

Haptically enhanced widget, haptic interaction, user interface extensible markup language, virtual reality.

## 1. INTRODUCTION

Although the visual channel probably is the most predominant modality for human-computer interaction in today’s computer-based systems, studying when and where an alternative modality may be used instead is still an open and interesting issue, whether this is for a normal user or a person with disabilities. Even more challenging is when the virtual channel could or should be part while offering a supplementary modality for non-visual interac-

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tion.

There has been much work to offer an audio rendering of web pages to blind users [1,5,8,9,15]. Even the best audio rendering still suffer from some intrinsic limitations such as: sequential navigation, long processing time, difficult navigation within a long page or across web pages, audio rendering is independent of any widget and only works when HTML is well-formed.

In contrast, haptic interaction displays the abilities to overcome some of these limitations: the user may, in principle, freely navigate within a scene provided that it has been designed to appropriately support haptic interaction (the haptic pointer may asynchronously move from an object to another) no sequence is imposed. Consequently, the time required to switch from one screen object to another object may be reduced at the price of a haptic exploration of the scene. Additionally, via haptic channel the blind users can have a perception of the structure of the virtual environment [12], in our case the 3D corresponding of a web page that is very close to the real one (it cannot be exactly the same because 3D rendering puts some limitations in positioning). This is a very important issue because it is essential not only to give blind people raw information but give them the opportunity to navigate through the internet in a way that makes navigation really interesting.

Haptic rendering must be easy-customizable as the specific needs of each user may differ from one another. The characteristics (shape, effects, surface properties, etc) of each component in a haptic environment have to be changeable. This customization is can be achieved with the use of UsiXML.

## 2. HAPTIC EXTENSION TO USIXML CUI MODEL

The semantics of UsiXML are defined in a UML class diagram. Each class, attribute or relation of this class diagram is transformed into an XML Schema defining the concrete syntax of the UsiXML language in general. A concrete user interface (CUI) is assumed to be expressed without any reference to any particular computing platform or toolkit of that platform.

The CUI model is composed of concrete interaction objects (CIO) and the relationships mapping them (cuiRelationship). The CIO model corresponds to an entity of the UI that is perceivable by the user (e.g., text, image, animation, sound, vocal output) and/or that allows users to interact graphically or vocally with the UI (e.g., a push button, a list box, a check box, a vocal input, vocal menu). Currently, the cio model considers the vocal and 2D graphical (2DGraphicalCio) modalities of interaction.

A complete description of this model could be found in the documentation of UsiXML ([www.usixml.org](http://www.usixml.org)).

The haptic CUI extension of UsiXML, Figure 1, corresponds to the description of haptic graphical concrete interaction objects

(HapticGraphicalCio). The new extension adds not just a new interaction type, the haptic, but also the 3-dimensional (3D) graphical representation.

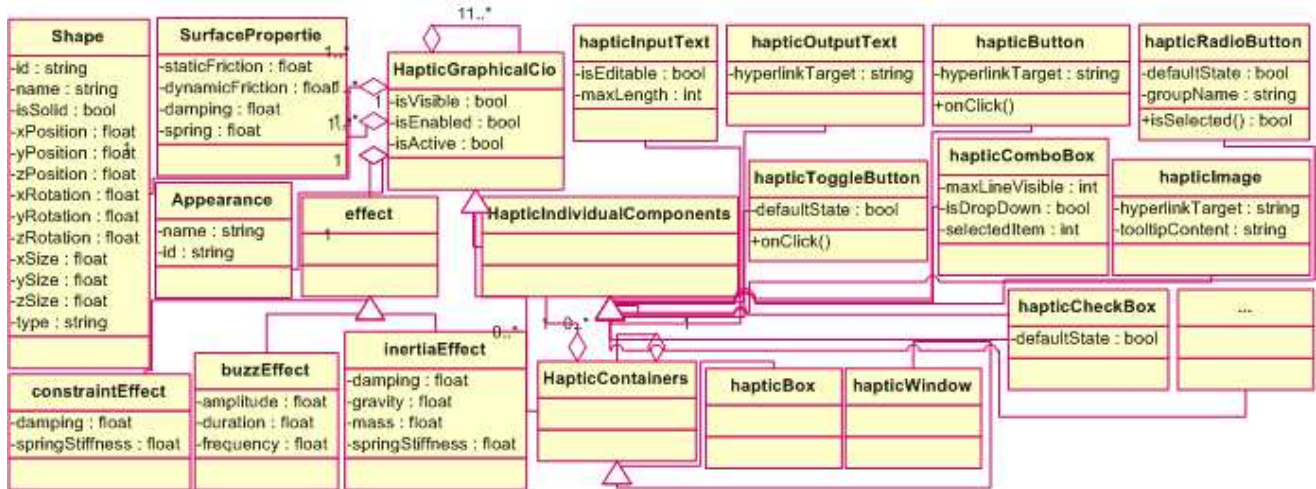


Figure 1 Haptic extension to UsiXML concrete user interface model

The haptic CUI model includes a set of effects:

- buzzEffect. The effect that vibrates the haptic machine.
- constraintEffect. This effect constraint the haptic machine to the point, line or plane using spring damping system.
- inertialEffect. This effect simulates inertial at the end point of the haptic machine as if a mass was a task there, using a spring/damping model.

The second component relevant to the haptic interaction is the *surface properties*. This model corresponds to the properties of the surface of the 3D haptic components. Its attributes are: static friction, dynamic friction, damping, spring. Finally, the shape model associated with the *HapticGraphicalCio* corresponds to the shape (*type*) of a haptic. Each shape is associated with an appearance, the surface, the sensors, for the behavior, all attributes compatible with the abstract definition of X3D language, proposed by web 3D consortium ([www.web3d.org](http://www.web3d.org)).

The HapticGraphical components are divided into HapticContainers and HapticIndividualComponents. For containers, currently, there are two implementations, the hapticWindow and hapticBox. The HapticIndividualComponents are haptic CIOs contained in a haptic container. These CIOs include: hapticTable, hapticTree, hapticImage, hapticMenu, hapticMenuItem, hapticSlider, hapticOutputText (a component specialized for output text), hapticInputText, hapticButton, hapticToggleButton, hapticCheckBox, hapticRadioButton, hapticComboBox and hapticItem.

### 3. IMPLEMENTATION OF THE HAPTIC RENDERING ENGINE

The complexity and the skills required to develop Graphical/Haptic (Multimodal) User Interfaces (GHUI) stress for a toolkit where native GHUI are provided to deploy a GHUI application.

In this section the procedure that was followed for the implementation of the haptic rendering engine is described. The main concept is that user gives a URL as input to the application, then some necessary transformations are executed and finally a 3D scene corresponding to the web page is being created.

First of all, the HTML file is transformed to an XHTML file so as it can be parsed as an XML file. For this transformation an open source tool which is called "Tidy" (<http://tidy.sourceforge.net/>) is used. After the XHTML file parsing, the corresponding 3D components are presented in the 3D scene. Additionally, a UsiXML file that describes the specific web page is generated. User can save this UsiXML file for further use. When the user loads a previously saved UsiXML file, the 3D scene is updated immediately. This procedure is shown in Figure 2.

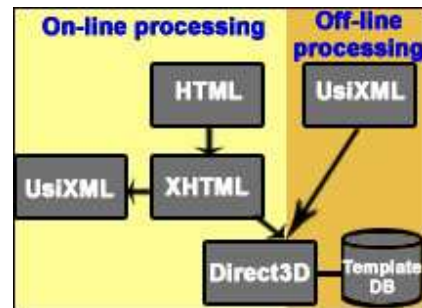


Figure 2 From HTML to a 3D scene

For the creation of the template DB, first off all, "Blender" (open source software for 3D modelling) was used to design a 3D shape for each component. Using "OGRE Meshes Exporter for Blender" (exporter to take animated meshes from Blender to Ogre XML), a .mesh file (binary file that represent a 3D model in a form that OGRE rendering engine understands) for each component was exported. Then, the .mesh files were imported in a C++ project using OGRE (Object-Oriented Graphics Rendering Engine) and

finally the 3D UsiXML components were presented in the 3D scene.

The target group of users includes people with normal vision as well as visual-impaired people. Due to this, the representations of the components had to be meaningful for both categories. For instance, an image has no meaning for a blind person but the description of the image (alternate text) has. For this purpose, a

speech synthesis engine was integrated to the haptic rendering engine so as to give blind people the opportunity to hear what they cannot read. A speech-recognition engine which offers the opportunity of inserting text without typing was also integrated. Additionally, earcons were used so as each widget can be identified by the unique short sound which is heard when the cursor touches one of the widget's surfaces.

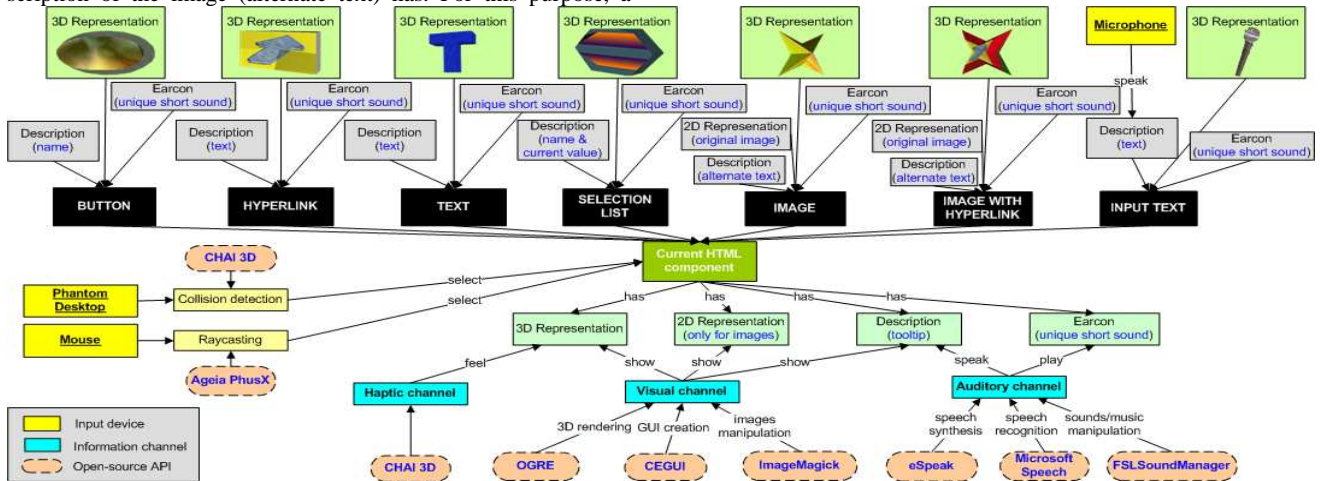


Figure 3 Haptic rendering engine's architecture

The application has mouse support for sighted people and Phantom support for blind users. When the user navigates through the 3D scene using the mouse, the raycasting technique is used for the component's selection while when he/she uses the Phantom the

collision detection technique is used (Figure 3). In the 3D scene every HTML component has a 3D representation, a description and an earcon.

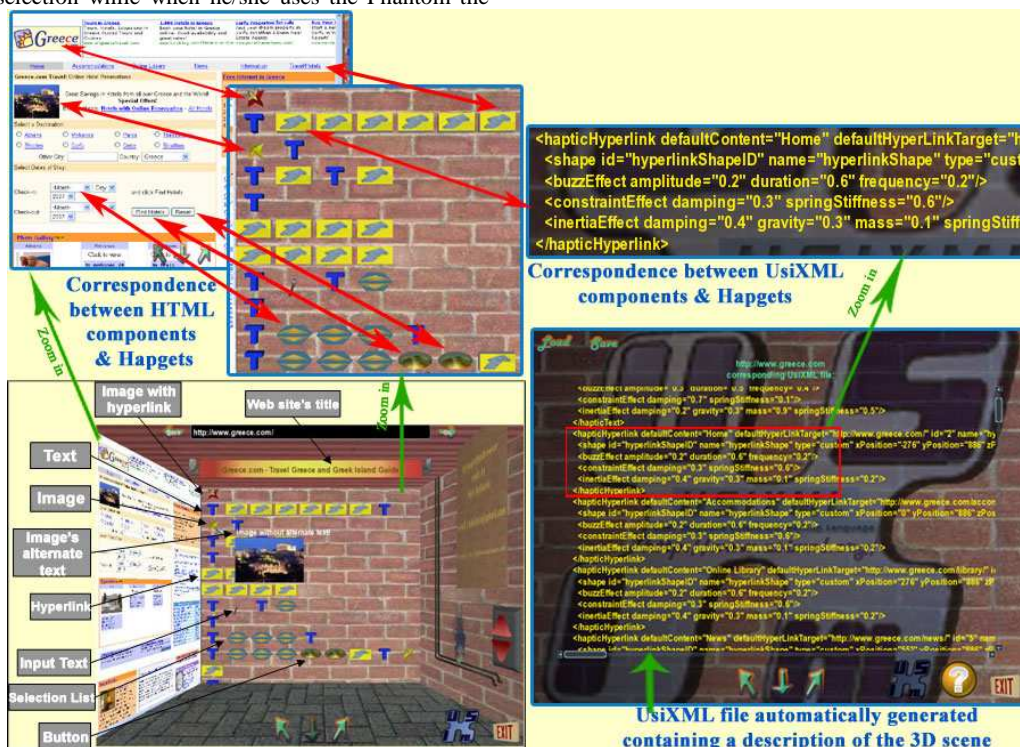


Figure 4 Test case: www.greece.com

For images, with or without hyperlink, there is also a 2D representation, which contains the original image.

When Phantom "touches" an object, the user immediately hears the earcon that corresponds to the objects of this type. If user



presses the LCTRL button of the keyboard while Phantom is in contact with an object, the object's description is being heard via the speech synthesis engine.

Figure 4 presents how the haptic rendering engine works. User starts the speech recognition engine (by pressing the SPACE button of the keyboard) and then gives a URL ("[www.greece.com](http://www.greece.com)" in this test case) using the microphone. The corresponding to this URL 3D scene is being created immediately.

At the left of the scene, user can see the web page as it is presented in a normal web browser. This side of the scene also interacts as a common web browser. For instance, user can click on a hyperlink and go to another URL with simultaneous update of the 3D objects presented in the scene.

There are some buttons that give user the opportunity to move in the 3D scene and focus on whatever he/she wants into the scene and many visual effects that make navigation through the internet much more impressive than it is via the typical web browsers. For instance, when the cursor goes over a 3D image, the original image shows up and the alternate text of the image is following the cursor as a 3D component's tooltip. However, all these features have to do with the users that have normal vision. The functionality that concerns the visual-impaired users is limited to the haptic and the auditory channel. A blind user can only interact with the 3D components via the haptic device (Phantom Desktop), hear all the necessary information via a speech synthesis engine and pass to the application all the necessary input via a speech recognition engine (using a microphone).

## 4. CONCLUSION

In this paper we describe a rendering engine to support haptic interaction. We also introduce "hapgets", which are three dimensional haptically-enhanced widgets. The goal of this paper is to describe the rendering engine, so, future work will be dedicated to analyze the graphical representation so as the interaction.

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## 6. REFERENCES

- [1] Avanzini, F., Crosato, P. 2006. Haptic-auditory rendering and perception of contact stiffness. In Proc. of 1<sup>st</sup> Workshop on Haptic and Audio Interaction Design HAID'2006 (Glasgow, August 31<sup>st</sup> - September 1<sup>st</sup>, 2006). Lecture Notes in Computer Science, Springer-Verlag, Berlin, 24-31.
- [2] Gonzalez Calleros, J.M., Vanderdonckt, J., and Muñoz Artega, J. (2006) A Method for Developing 3D User Interfaces of Information Systems. In Proc. of 6<sup>th</sup> Int. Conf. on Computer-Aided Design of User Interfaces CADUI'2006 (Bucharest, June 6-8, 2006). Springer, Berlin, 85-100.
- [3] Limbourg, Q., Vanderdonckt, J., Michotte, B., Bouillon, L., and Lopez-Jaquero, V. 2004. UsiXML: a Language Supporting Multi-Path Development of User Interfaces. In Proc. of Int. Conf. on Design, Specification, and Verification of Interactive Systems EHCI-DSVIS'2004 (Hamburg, July 11-13, 2004). Lecture Notes in Computer Science, Vol. 3425, Springer-Verlag, Berlin, 207-228.
- [4] Mao, X., Hatanaka, Y., Imamiya, A., Kato, Y., and Go, K. Visualizing Computational Wear with Physical Wear. In Proc. of 6<sup>th</sup> ERCIM Workshop on "User Interfaces for All" (Florence, October 25-26, 2000).
- [5] Magnusson, C., Danielsson, H., and Rasmus-Gröhn, K. 2006. In Proc. of 1<sup>st</sup> Workshop on Haptic and Audio Interaction Design HAID'2006 (Glasgow, August 31<sup>st</sup> - September 1<sup>st</sup>, 2006). Lecture Notes in Computer Science, Springer-Verlag, Berlin, 111-120.
- [6] Magnusson, C., Tan, Ch., and Yu, W. Haptic access to 3D objects on the web. In Proc. of EuroHaptics'06.
- [7] Molina, J.P., Vanderdonckt, J., Montero, F., and Gonzalez, P., Towards Virtualization of User Interfaces based on UsiXML. In Proc. of 10<sup>th</sup> ACM Int. Conf. on 3D Web Technology Web3D'2005 (Bangor, March 29-April 1, 2005). ACM Press, New York, 169-178.
- [8] Ramstein, C. and Century, M. Navigation on the Web using Haptic Feedback. In Proc. of the Int. Symposium on Electronic Art ISEA'96.
- [9] C. Ramstein O. Martia, A. Dufresne, M. Carignan, P. Chassé and P. Mabileau, "Touching and hearing GUIs - Design Issues", in *PC-Access systems. Proceedings of the International conference on assistive technologies ACM/SIGCAPH ASSETS'96*, ACM, 1996, pp. 2-9.
- [10] E. Sallnäs, K. Bjerstedt-Blom, F. Winberg and K. Severinsson-Eklundh, "Navigation and Control in Haptic Applications Shared by Blind and Sighted Users", in *proc. of 1st workshop on haptic and audio interaction design*, David McGookin & Stephen Brewster (eds.), LNCS, Springer-Verlag, Glasgow, 31st August - 1st September, 2006, pp. 68-80.
- [11] V. Tikka, P. Laitinen, "Designing Haptic Feedback for Touch Display: Experimental Study of Perceived Intensity and Integration of Haptic and Audio", in *proc. of 1st workshop on haptic and audio interaction design*, David McGookin & Stephen Brewster (eds.), LNCS, Springer-Verlag, Glasgow, Scotland, 31st August - 1st September 2006, pp. 36-44
- [12] D.Tzovaras, G.Nikolakis, G.Fergadis, S.Malasiotis and M.Stavrakis: "Design and Implementation of Haptic Virtual Environments for the Training of Visually Impaired", *IEEE Trans. on Neural Systems and Rehabilitation Engineering*, Vol. 12, No. 2, pp.266-278, June 2004.
- [13] J. Vanderdonckt, "A MDA-Compliant Environment for Developing User Interfaces of Information Systems", in *Proc. of 17th Conf. on Advanced Information Systems Engineering CAiSE'05*, O. Pastor & J. Falcão e Cunha (eds.), Lecture Notes in Computer Science 3520, Springer-Verlag, Porto, Portugal, 13-17 June, 2005, pp. 16-31
- [14] S. A. Wall and S. A. Brewster, "Assessing Haptic Properties for Data Representation", to appear in *Proceedings of ACM CHI 2003*, ACM, Fort Lauderdale, USA.
- [15] W. Yu, D. Reid and S. A. Brewster, "Web-Based Multimodal Graphs for Visually Impaired People", in *Proceedings of the 1st Cambridge Workshop on Universal Access and Assistive Technology (CWUAAT)*, Cambridge, UK, pp.97-108.