Towards a Formalized Process for Creating Haptic Data Visualizations

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ABSTRACT

Haptic Data Visualization (HDV) is a novel application of haptics. It provides functionality by which users touch and feel data, making it a useful tool for users with vision impairments. However, creating such visualizations usually requires programming knowledge, that support workers and tutors of blind users may not possess. To address this issue we propose a formalized process for creating HDVs using the HITPROTO [5] toolkit, which requires no programming experience. We further illustrate this process using an example HDV.

Keywords: Haptics for Visualization, Interaction Design, Multimodal Input Devices.

Index Terms: H.5.2 [Information Interfaces and Presentation]: User Interfaces—Haptic I/O

1 INTRODUCTION

Haptic devices are becoming popular, as haptic and tactile technologies find their way into consumer electronics. One novel area of haptics is haptic data visualization (HDV), where data can be felt in three dimensions using a tactile or force-feedback, computer-operated device. The aim of this application is twofold: firstly it allows users with vision impairments to feel the data; secondly it provides a holistic view through touch and feel along with the visual modality for those with no impairments.

Current visualization practices for users with vision impairments fall into two categories. Either tutors use special materials, like paper with tactile engravings corresponding to printed areas – a relatively cheap method – or programmers create bespoke demonstrations. The latter method enables dynamic alteration of the visualizations and enhanced interaction; however it requires specialized programming knowledge of a haptic API. While it is fairly easy to create a 3D scene-graph into a haptic world, adding interaction through a haptic device is fairly tedious.

Our approach is to allow support workers and tutors of users with vision impairments to use a specialized toolkit, named HITPROTO [5] that allows them to create HDVs through a simple visual programming interface. Subsequently, these HDVs can be felt haptically by users, in order to understand the underlying data.

Through this approach tutors are able to create various data representations that would have not been possible with static tactile-graphic methods and guidance interactions can help users to focus on prominent visualization features. In addition, the system can be used for distance learning where a mentor creates the visualizations remotely from the mentee and sends them to the latter to use locally.

HDV presents a series of challenges, mainly due to the fact that the haptic channel conveys less information, compared to visual mechanisms. Consequently, there is a need to abstract or idealise

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information in order to map them to haptic variables [5]. The choice of haptic variables is also important as it has direct consequences on how users can interact with the visualization. Last but not least, the interaction itself affects how the users explore the dataset, say by scaling or modifying aggregations. A comprehensive review of designs for HDV is presented by Panëels and Roberts [6].

2 RELATED WORK

The areas of HDV is influenced by tactile, static representations, tactile and force-feedback interfaces and haptic interacting systems prototyping. Way and Barner [8] present an automatic process for creating tactile graphics from images, introducing ideas followed by other researchers in creating automatic systems (e.g., [7]). Several institutes provide guidelines on the creation of tactile graphics for the visually impaired (e.g., [4]) pinpointing the need to omit unnecessary features, abstracting complex representations with behaviours (e.g., textures to represent different areas) and simplifying where possible the graphics. Various technologies, such as thermoform, vacuum-form, microcapsule paper and even Wikki Stix have been used in this context.

Tactile and force-feedback interfaces have gained growth during the 1990s, due to their use in home gaming and smart-phones, with many examples achieving realistic tactile feedback. A comprehensive review of tactile technologies can be found in [1]. Force-feedback systems, on the other hand, have been used to explore haptically scientific datasets, like the GROPE project [2] used for molecular modelling. In recent years devices like Geomagic's Touch and Touch X (formerly Sensable PHANToM Omni and Desktop, respectively), used in this research (see Figure 1), and Novit Falcon have also become very popular in haptics research.

Prototyping has been scarcely used in the field of haptics, with most examples focusing on developing a haptic model of an environment and not focusing on the behaviour in, or interactions with it. A recent system providing a simple programming interface for haptic interactions is HapticTouch [3]. However, our approach focuses specifically on HDV, aiming to allow tutors to develop haptic interactions without requiring any programming experience.

3 THE HITPROTO TOOLKIT

Our proposed process for creating HDVs is based on the use of the HITPROTO toolkit [5]. HITPROTO attempts to simplify the process of creating HDVs by providing a visual programming interface. It uses H3DAPI, an open-source haptics software development platform that uses OpenGL and X3D. The HITPOTO design process itself has three steps: (1) The user creates an HDV sce-

Figure 1: The Geomagic Touch (Sensable PHANToM Omni).

(a) The HDV creation process

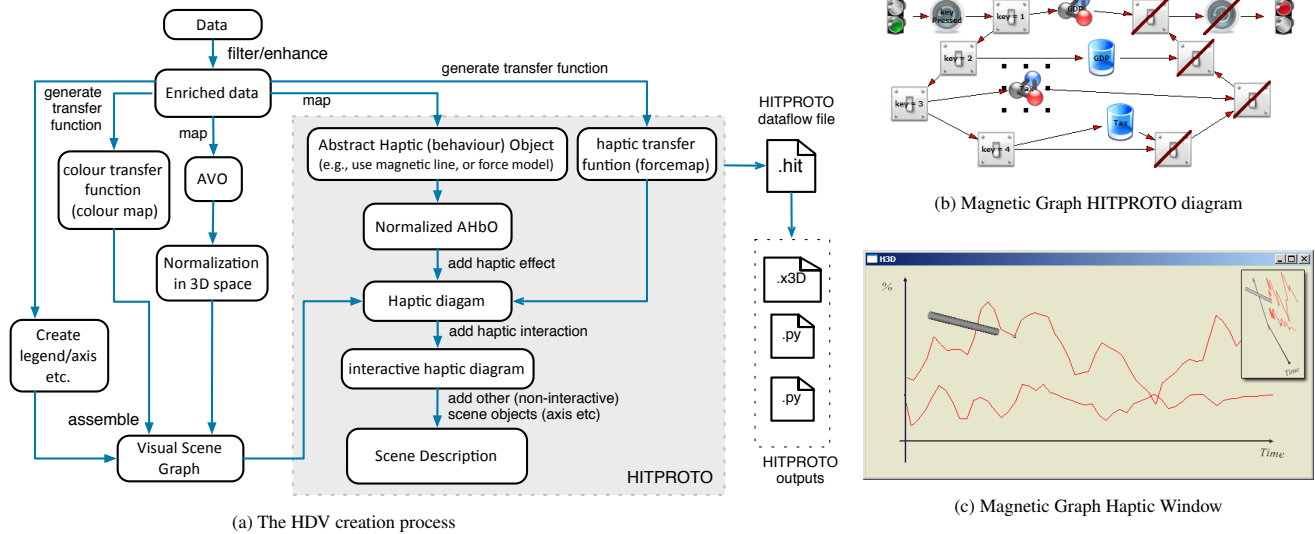(b) Magnetic Graph HITPROTO diagram

(c) Magnetic Graph Haptic Window

Figure 2: The HDV process from data acquisition to haptic visualization (Figure 2a), used to create the '*UK Public Spending since 1963 example*', with a HITPROTO diagram shown in (Figure 2b). Keys '1' and '2' display the 'Spending, % of GDP' and the 'Tax Receipts, % of GDP', annually. The produced HDV (Figure 2c) can be visualized (and interact with) using H3DLoad or the HITRPOTO internal viewer. The Graph can be viewed in 3D (inset). Data obtained from the Guardian, original source HM Treasury.

nario by connecting and parametrising modular blocks – describing specific behaviours (e.g., magnetic lines, spirng effects etc.) – together on the HITPROTO canvas, (2) the diagram is saved in a distributable .hit XML-like file and (3) HITPROTO generates a H3D Python file, and H3DAPI is used to execute the haptic scene. X3D scenes can also be loaded, complementary to diagrams. Haptic behaviour can be assigned on the scenes objects.

3.1 The HDV Creation Process

The proposed HDV process extends traditional 2D/3D visualization methods in the 3D space, adding haptic behaviours and interaction through devices such as the PHANToM Omni. The process involves mapping the enriched dataset to an Abstract Haptic (behaviour) Object (AHbO) that uses some form of a haptic behaviour (e.g., magnetic field, spring effect, force model), deriving a haptic transfer function for the applied force model and normalizing the AHbO in the operational space of the haptic device (essentially a 3D box). A haptic diagram is then built using the HIT-PROTO toolkit where the mentor chooses the blocks corresponding to the chosen haptic effect. The diagram can include either a X3D scene with named objects and assigned behaviour, referencing those names or blocks that model the graphical representation as well as the haptic behaviour – like the Haptic Effect block with the Magnetic Lines behaviour option.

Additional interactions using the keyboard, mouse or haptic device button can also be added in the HITPROTO diagram, adding another level of control to the HDV. Finally, objects like legends and axis can be added as X3D elements. These objects may or may not exhibit haptic behaviour depending on the tutor's design.

Using this process, we have created an HDV depicting the UK public spending since 1963 (Figure 2). The HDV is using the Haptic Effect block, displaying two magnetic lines depicting different graph features, along with keyboard interaction for switching the haptic effect from one graph to the other and a complementary X3D scene for displaying the axes. One enhancement we identified, through preliminary testing, is the need to add a haptic guidance to a point on the graph for visually impaired users. More complex examples of HDVs produced with this process are demonstrated by Panëels et al. [5].

4 CONCLUSION

We present a process for creating haptic data visualizations, targeted to users with visual impairments. The creation process of these HDVs does not require any programming knowledge and thus can be easily created by tutors and support workers. The resulting HDVs are felt hapticaly using H3DAPI and a haptic device such as PHANToM Omni. We present an example of such an HDV; a magnetic graph of the UK Public Spending since 1963.

There are many opportunities for future work, e.g., the perception of magnitude and value information through haptics alone is difficult and thus integrating on-demand audio feedback in the prototyping process, to report hapticaly 'touched' values, could provide an appropriate solution. With the development of new interface technologies there is an opportunity to integrate additional sensory modalities into information visualization, especially to assist comprehension and exploration tasks.

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