

Towards a Formalized Process for Creating Haptic Data Visualizations

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INTRODUCTION

Haptic Data Visualization (HDV) provides functionality for users to touch and feel data in 3D using a tactile or force-feedback device.

HDV has a two-fold aim:

- users with vision impairments to feel data
- enhancing data perception for any user.



The Geomagic Touch (PHANToM Omni)

MOTIVATION

Current practices:

- mentors use special materials, like engraved/embossed paper
- programmers create bespoke haptic demonstrations.

However, coding is difficult and time consuming.

We propose a formalized process for creating HDVs using the HITPROTO [1] toolkit, enabling mentors to create HDVs through a simple visual programming interface.

CHALLENGES

The haptic channel conveys less information, compared to visual mechanisms:

- there is a need to abstract information for mapping them to haptic variables [1]
- choice of haptic variables has direct consequences on interaction
- interaction complexity affects dataset exploration

A comprehensive review of designs from HDV can be found in [2].

FUTURE WORK

The work on HDVs is ongoing, including to devise mechanisms that assist the perception of magnitude and value. Future versions of the HITPROTO toolkit will complement HDVs with on-demand audio feedback to report the haptically ‘touched’ value.

REFERENCES

- [1] S. A. Panéels, P. D. Ritsos, P. J. Rodgers, and J. C. Roberts. Prototyping 3D haptic data visualizations. *Computers & Graphics*, 37(3):179-192, 2013.



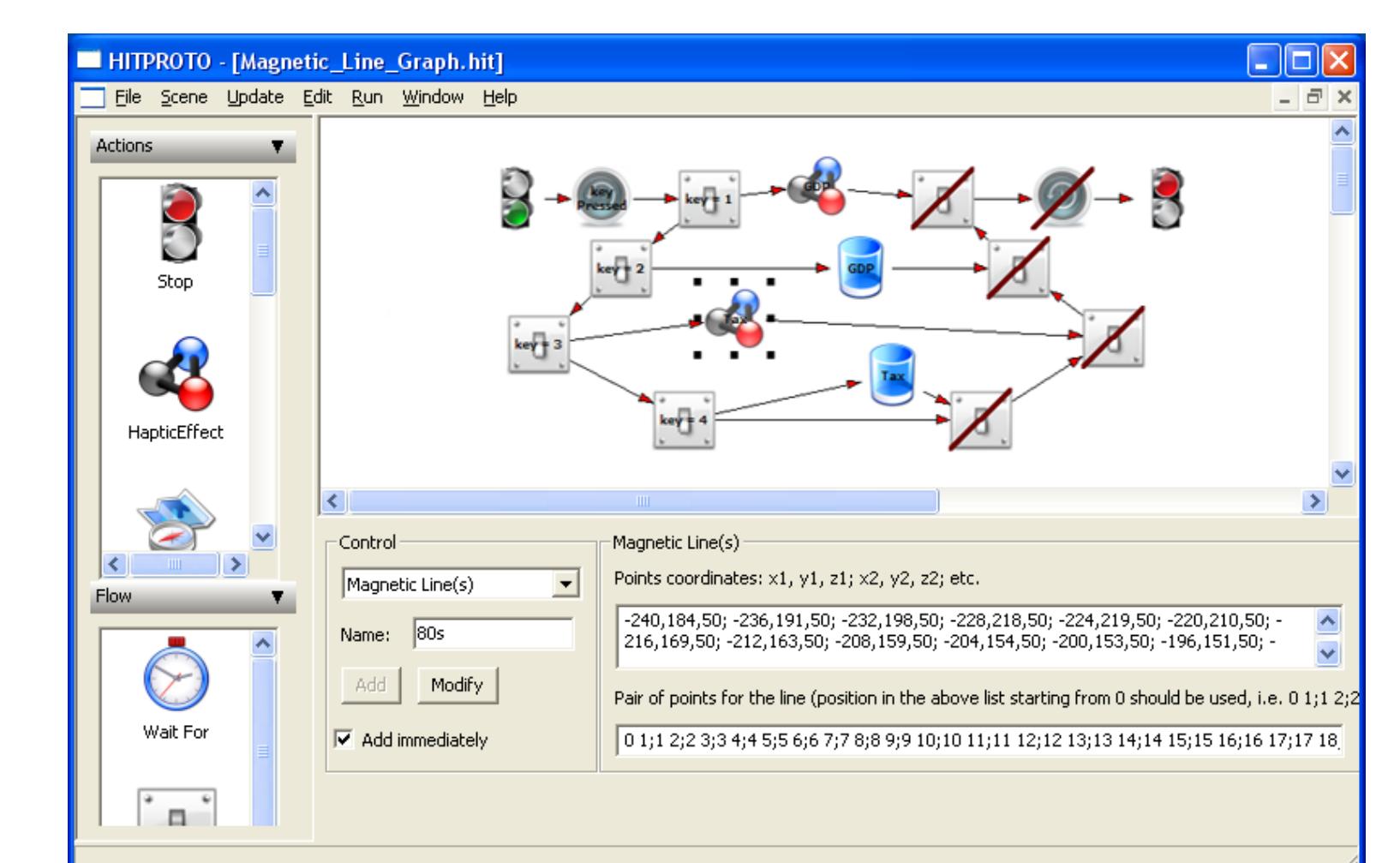
- [2] S.A. Panéels and J.C. Roberts. Review of designs for haptic data visualization. *IEEE Transactions of Haptics*, 3(2):119-137, 2010.



THE HITPROTO TOOLKIT

HITPROTO provides a visual programming interface for creating HDVs and is based on H3DAPI – an open-source haptics API that uses OpenGL and X3D.

The Geomagic Touch (shown on the left) can be used to interact with the HDV. Other devices compatible with H3DAPI are also supported.



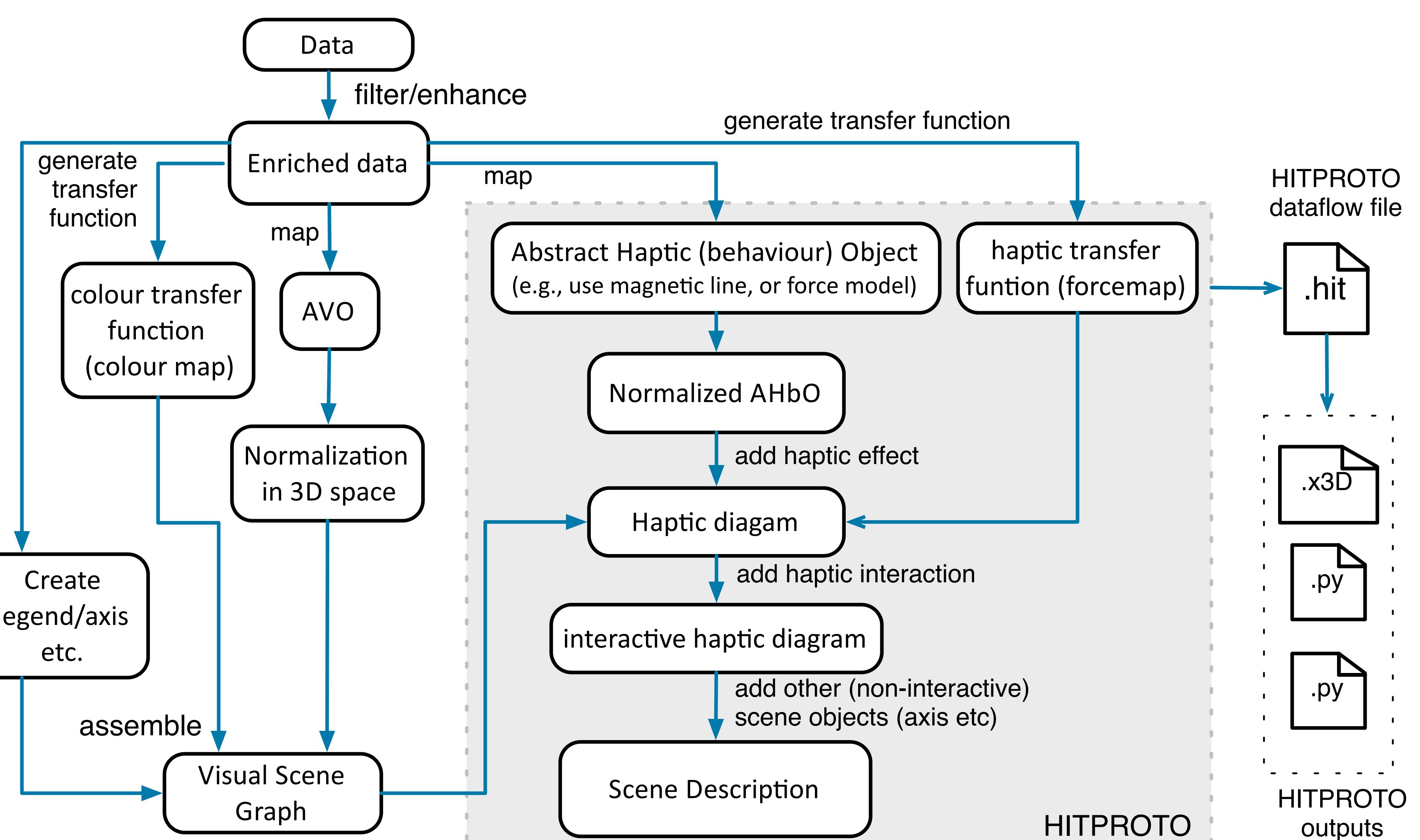
The HITPROTO work-flow has three main steps:

- i) the user builds an HDV diagram by connecting and parametrising modular blocks – modeling haptic behavior and/or assigning haptic behavior on X3D objects
- ii) the diagram is saved as a distributable, re-loadable, XML-like file (.hit)
- iii) a H3D Python file is generated and the H3DAPI is used to execute the haptic scene

X3D objects modeling legends/axis can also be loaded, complementary to diagrams.

THE HDV CREATION PROCESS

The proposed HDV process extends traditional 2D/3D visualization methods and adds haptic behaviour and interaction through devices such as the Geomagic Touch.

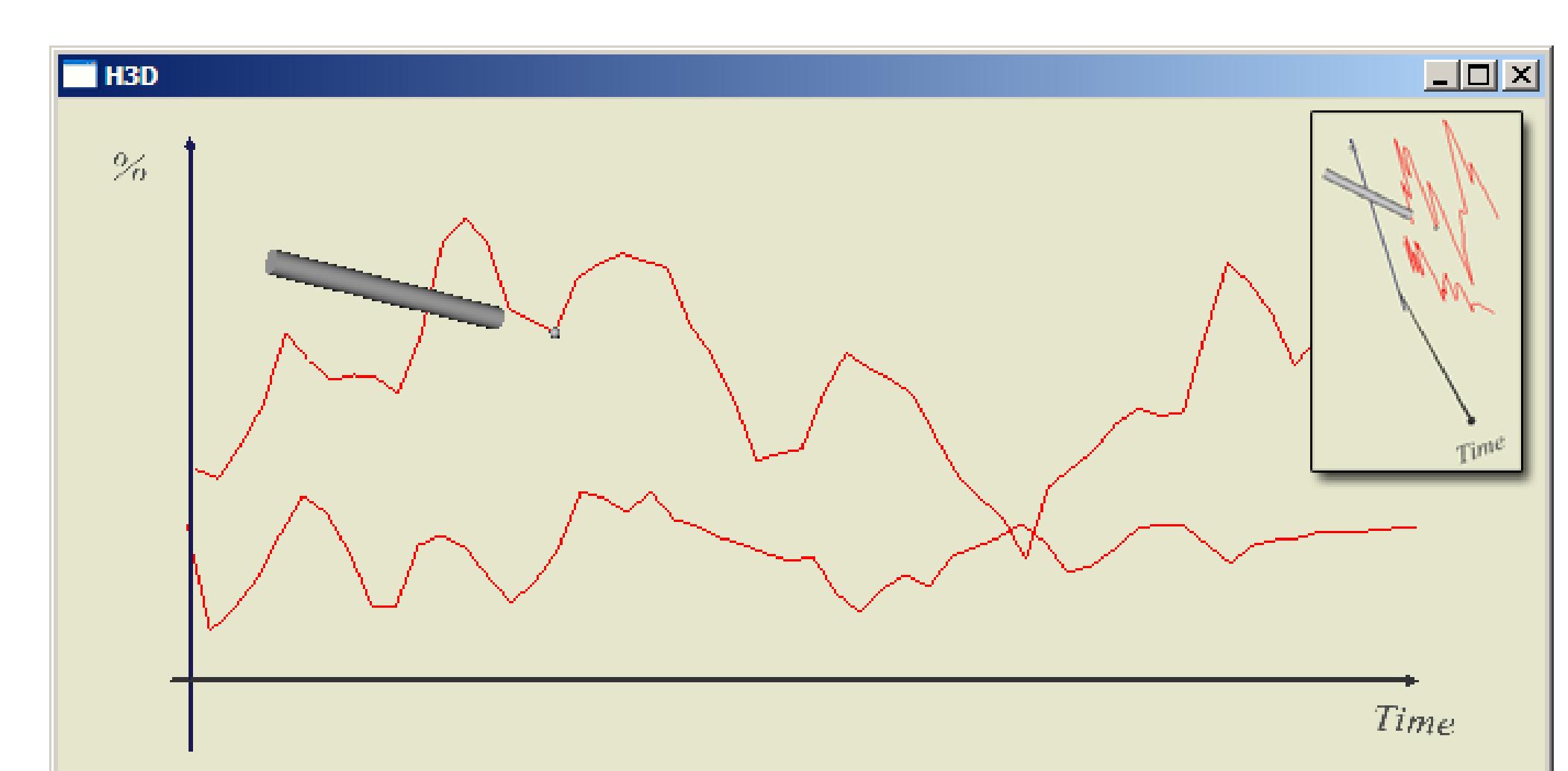


EXAMPLE HDVs

Magnetic Line Graph - UK Public Spending since 1963 (Data obtained from the Guardian, original source HM Treasury.)

The HDV diagram (shown on the HITPROTO Toolkit section) comprises of:

- two Haptic Effect blocks, displaying magnetic lines depicting two graphs – the annual ‘Spending, % of GDP’ and the ‘Tax Receipts, % of GDP’.
- a complementary X3D scene for the axes.
- keyboard interaction (keys ‘1’ & ‘2’) for enabling the haptic effect for each graph



Force-Model Scatter Plot - Iris dataset by R.A. Fisher (<http://lib.stat.cmu.edu/DASL/Stories/Fisher'sIris.html>)

Haptic scatter plot using the Force Model. The resultant force is given by Eq.1 where d_i , the distance from point i to the device pointer \vec{u}_i , the unit vector of the vector from the device to point i . The model is shown in (2).

$$\vec{F} = -k \times \sum_{i=1}^n \frac{1}{d_i} \times \vec{u}_i . \quad (1)$$

