

# H3DAPI

Downloadable at [www.h3d.org](http://www.h3d.org)

## The open source platform for multimodal development

H3DAPI is an open source haptics software development platform that uses the open standards OpenGL and X3D with haptics in one unified scene graph to handle both graphics and haptics. H3DAPI is cross platform and haptic device independent. It enables audio integration as well as stereography on supported displays.

Unlike most other scene graph APIs, H3DAPI is designed chiefly to support a special rapid development process. By combining X3D, C++ and the scripting language Python, H3DAPI offers three ways of programming applications that offer the best of both worlds – execution speed where performance is critical, and development speed where performance is less critical.

H3DAPI is written in C++, and is designed to be extensible, ensuring that developers possess the freedom and means to customize and add any needed haptics or graphics features in H3DAPI for their applications.

H3DAPI has been used to develop a diverse range of haptics and multimodal applications in various fields including but not limited to dental, medical, industrial and visualization. To encourage learning and growth in the use of haptics technology, H3DAPI is open source and released under the GNU GPL license, with options for commercial licensing.



### Key advantages of using H3DAPI

- ✓ Enables rapid development of haptic applications using X3D and Python
- ✓ Easily extended with custom haptic-visual features using C++
- ✓ Supports a wide range of haptic devices in the market
- ✓ Devices from different manufacturers can be run at the same time in the same scene
- ✓ Supports most 3D stereo display systems
- ✓ Runs on all popular platforms including Windows, Linux and Mac OSX
- ✓ Offers freedom and choice of haptics renderers including H3D point and sphere-based renderers, SensAble OpenHaptics, Chai3D
- ✓ Comes with a range of built-in forces and surfaces

## H3DAPI Architecture

Essentially H3DAPI is a layer which encapsulates graphics and haptics into one platform and implements X3D and Python as an interface for application development (**Figure 1**). The combination of haptics and graphics into one scene graph ensures that the software developer need not be unnecessarily inconvenienced by the task of extending either haptic or graphic components to work with the other, but could instead focus on application development.

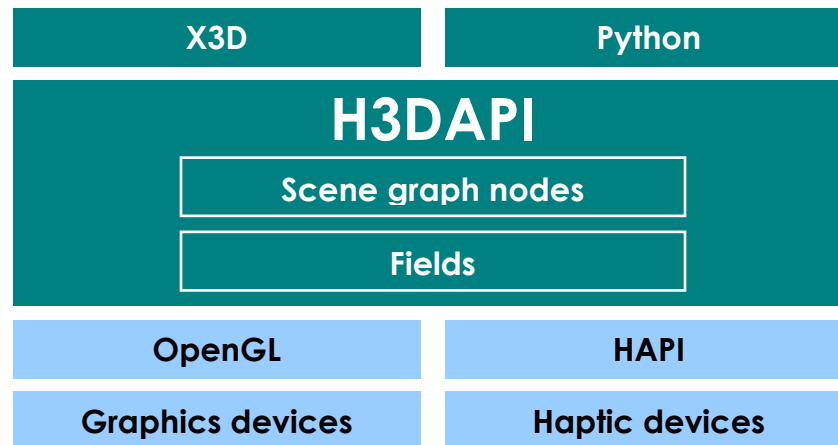


Figure 1 H3DAPI architecture

One of the important features of H3DAPI is that it provides flexibility to the developer beyond X3D and Python scripting. H3DAPI is designed to be modular and easily extensible, so more advanced developers can do lower level graphics and haptics programming with C++.

HAPI is created by SenseGraphics, the team behind H3DAPI. Like H3DAPI, HAPI is open source.

H3DAPI comes packaged with HAPI. HAPI is available as a standalone haptics engine at [www.h3d.org](http://www.h3d.org)

H3DAPI uses OpenGL for graphics rendering and the Haptics API (HAPI) for haptics. HAPI is the haptics engine which supplies the haptics capabilities to H3DAPI. Like H3DAPI it is written in C++ and designed to be highly modular. HAPI comprises four main parts, each of which can be easily extended to meet individual needs:

- 1) **Device handling** which enables HAPI to work with different haptic devices
- 2) **Geometry based haptics**, consisting of three subparts: collision handling, haptic rendering algorithm, and surface interaction algorithm
- 3) **Free space haptics**, with a collection of force effects
- 4) **Thread handling**

Four haptics rendering algorithms, targeted at point-based 3DOF haptics, are implemented in HAPI: SensAble OpenHaptics, Chai3D, and two H3D point and sphere-based renderers. This means that users of H3DAPI are able to choose from any of these for haptics renderers, even including their own written rendering algorithms. HAPI presents the possibility of implementing a user-written 6DOF haptics rendering algorithm as well.

## Rapid Development with H3D API

One of the advantages of H3D API is its use of X3D, the ISO certified open standard scene graph design. As a consequence most graphics software are able to save to the X3D format, which can then be imported and used in H3D API. This allows users to conveniently add haptics to existing graphics.

Even for the inexperienced, haptics development with H3D API is not particularly difficult. **Figure 2** shows the H3D code which creates a box with surface haptics. Experienced X3D programmers will find that H3D programming is not much different from X3D programming. H3D codes are saved to files with the .x3d extension.

```
<Group>
  <Shape>
    <Box DEF="MyBox" size="0.1 0.1 0.1" />
    <Appearance>
      <Material diffuseColor="1 0 0" />
      <FrictionalSurface dynamicFriction="0.5" />
    </Appearance>
  </Shape>
</Group>
```

**Figure 2** Code to create a box with frictional surface

In H3D API, Python scripting is used in addition to X3D to express more behaviors and animation in the scene. The code in **Figure 3** changes the color of the box from red to green whenever it is touched by the haptic device. The use of X3D and the interpreted language Python eliminates the need for the write-compile-debug cycles of compiled languages, and it is possible to cut development time by more than half when compared to using only C++.

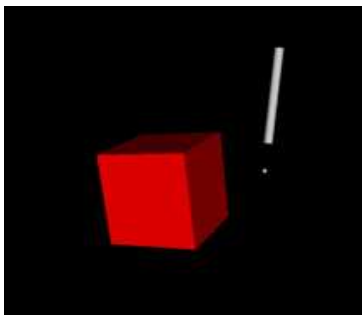
```
<Group>
  <Shape>
    <Box DEF="MyBox" size="0.1 0.1 0.1" />
    <Appearance>
      <Material DEF="BoxM" diffuseColor="1 0 0" />
      <FrictionalSurface dynamicFriction="0.5" />
    </Appearance>
  </Shape>
  <PythonScript DEF="PS" url="script.py" />
  <ROUTE fromNode="MyBox" fromField="isTouched"
        toNode="PS" toField="changeColor" />
  <ROUTE fromNode="PS" fromField="changeColor"
        toNode="BoxM" toField="diffuseColor" />
</Group>
```

**Figure 3a** Code added to that in Figure 2 (in gray) for interaction. The PythonScript node uses the script in Figure 3b to define interaction.

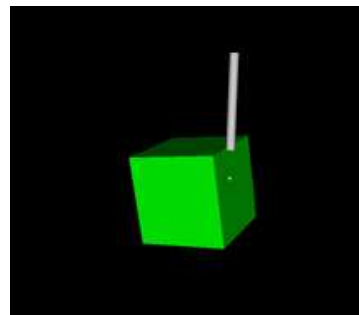
```
from H3DInterface import *
class ChangeColor(TypedField(SFColor, MFBool)):
    def update(self, event):
        if len(event.getValue()) > 0 and \
            event.getValue()[0]:
            return RGB(0, 1, 0)
        else:
            return RGB(1, 0, 0)
changeColor = ChangeColor()
```

**Figure 3b** The file script.py which contains the Python script to define changes in box color.

Result of the code and script from Figure 3:



Box is red when  
untouched



Color changes to  
green when box  
is touched

## Customization and Extension with C++

All H3D API scenes and interaction written in X3D and Python can also be recreated in C++ using the H3D nodes and fields libraries. However, the power of C++ programming lies most in the extensibility and customizability of H3D API. With C++ there is flexibility for the developer to:

- modify existing nodes and fields for both graphics and haptics
- extend H3D API with the addition of new nodes and fields
- modify or add haptics rendering algorithms, force effects, surface haptics

## Why use H3D API

Reproducing the sense of touch in a computer simulation is still a relatively new technology and there are very few scene graph based APIs that offer touch rendering. H3D API is the ideal tool to begin writing applications that combine the sense of touch with vision, primarily because of the unified scene graph, and the support for many industry and de facto standards (OpenGL, X3D, SensAble OpenHaptics) and hardware in the marketplace.

### Supported devices

- SensAble PHANTOM devices
- Force Dimension Omega devices
- Force Dimension Delta devices
- Novint Falcon
- MOOG FCS HapticMaster
- G-Coder Systems Simball

### Haptics features

#### Surfaces

- DepthMapSurface
- SmoothSurface
- FrictionalSurface
- MagneticSurface
- OpenHapticsSurface

#### Force effects

- ForceField
- MagneticGeometryEffect
- PositionFunctionEffect
- SpringEffect
- TimeFunctionEffect
- ViscosityEffect

### Supported stereographic displays

- Arisawa/Hundai 24" PW240 LCD Display
- CRT > 100Hz with stereographics shutter glasses
- Infitec dual projection setup
- SeeReal 3D displays
- DepthO active 3D stereo projector
- Projectiondesign 3D projectors
- Sharp display

### Supported stereo modes

- Quad buffered
- Horizontal split
- Vertical split
- Horizontal interlaced
- Vertical interlaced
- Red-blue stereo
- Red-cyan stereo

(all supported modes can be mirrored in Y or operate on fullscreen)

H3D API has been found to be useful for the following reasons:

- ✓ open source
- ✓ unified graphics and haptics scene graph
- ✓ multiple hardware support
- ✓ rapid prototyping

## Applications and projects using H3DAPI

- ✓ Dental simulator by MOOG FCS (The Netherlands)
- ✓ Bone drilling surgical simulators by MedicVision (Australia)
- ✓ Needle insertion and injection simulator by Initium (United Kingdom)
- ✓ Stroke rehabilitation stations by Curictus (Sweden)
- ✓ Haptics in education , Armstrong Atlantic State University (United States)
- ✓ Spinal anesthesia training, Cork University Hospital and University of Limerick
- ✓ Neuroscience and rehabilitation, Innovative Sports Training
- ✓ Virtual reality applications, Iowa State University
- ✓ Visualization projects, Norrköping Visualization and Interaction Studio
- ✓ Interventional radiology training, University of Wales Bangor
- ✓ Medical image segmentation, Uppsala University
- ✓ And many more...



SenseGraphics provides training courses to help developers get started with H3DAPI. The basic course covers:

- ✓ Part 1: Introduction, H3DAPI, Graphics, Haptics
- ✓ Part 2: Field and event handling
- ✓ Part 3: H3D scene graph and nodes
- ✓ Part 4: X3D programming for H3D
- ✓ Part 5: Python for H3D
- ✓ Part 6: C++ for H3D

The courses may be customized on request.

## Licensing Options

The open source H3DAPI is free for use under the GNU General Public License and is downloadable at [www.h3d.org](http://www.h3d.org). H3D.org is the open source H3D community where users can participate in forum discussions, find H3DAPI support, documentation, plugins and extensions, and report bugs.

Commercial licenses are also available for H3DAPI and HAPI. Contact [info@sensegraphics.com](mailto:info@sensegraphics.com) for more information.

## About SenseGraphics

SenseGraphics' vision is to facilitate the development of haptic, and co-located haptic-visual applications. In addition to H3DAPI and HAPI, SenseGraphics provides immersive workbenches, and software and hardware solutions for multimodal applications. SenseGraphics also offers training, consulting and application development services.

# SenseGraphics

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