

Add 3D Touch™ Navigation and Haptics to Your Applications

Create a compelling user experience. Enable users to go beyond working with a 2D mouse, to interact with and manipulate objects in a more realistic fashion. Allow users to feel objects in a scene, making applications more intuitive and easier to learn. Give users true 3D navigation and direct interaction in a way that makes them more productive and adds a “wow” factor to your application.

The **OpenHaptics® toolkit** enables software developers to add haptics and true 3D navigation to a broad range of applications, including 3D design and modeling, medical, games, entertainment, visualization, and simulation. This haptics toolkit is patterned after the OpenGL® API, making it familiar to graphics programmers and facilitating integration with OpenGL applications. Using the OpenHaptics toolkit, developers can leverage existing OpenGL code for specifying geometry and supplement it with OpenHaptics commands to simulate haptic material properties such as friction and stiffness. The extensible architecture enables developers to add functionality to support new types of shapes. This toolkit is also designed to integrate third-party libraries such as physics/dynamics and collision detection engines. The OpenHaptics toolkit supports the range of SensAble™ PHANTOM® devices, from the low-cost PHANTOM Omni® device to the larger PHANTOM Premium devices. The OpenHaptics toolkit supports Microsoft® Windows® XP and 2000, Linux®, and Macintosh OS® X Platforms.

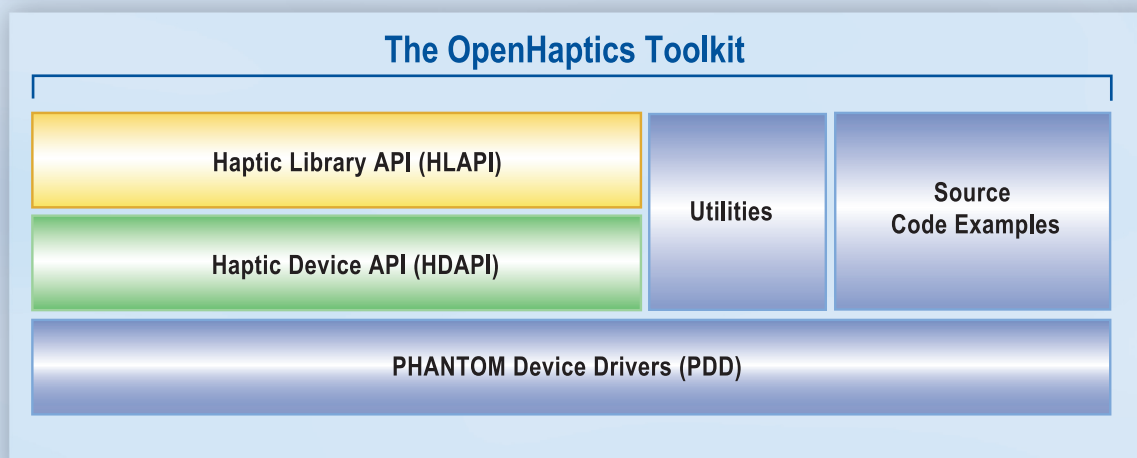
ALSO AVAILABLE

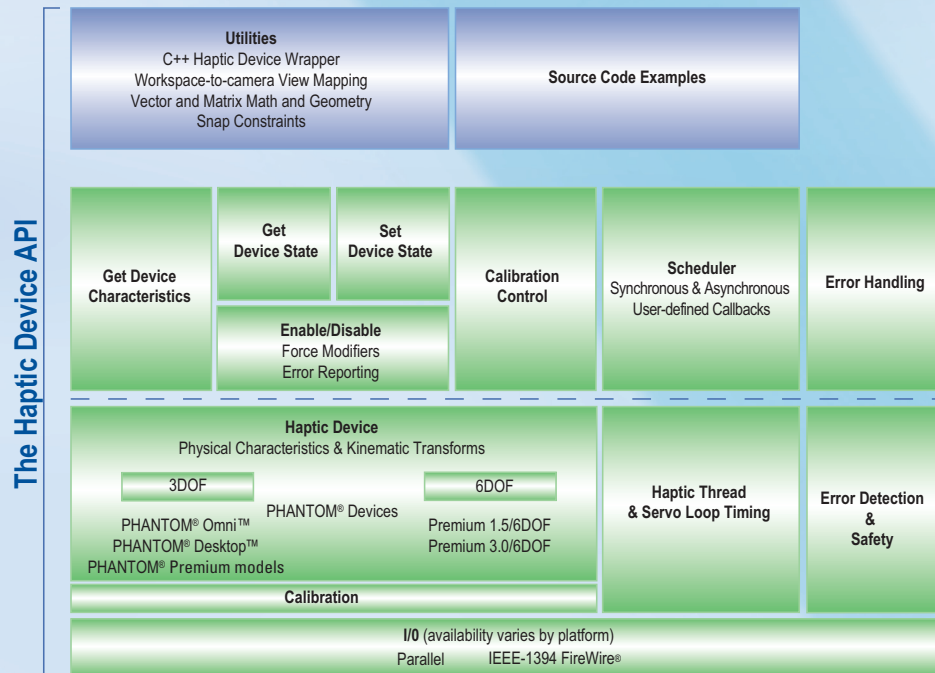
*OpenHaptics Academic Edition with special licensing.
See www.sensable.com for details.*

```
// display method for "HelloHaptics" program
void display(void)
{
    hlBeginFrame();
    glClear(GL_COLOR_BUFFER_BIT | GL_DEPTH_BUFFER_BIT);
    glColor3f(1.0,0.0,0.0);
    hlBeginShape(HL_SHAPE_DEPTH_BUFFER, myShapeId);
    glBegin(GL_POLYGON);
        glVertex3f(0.25, 0.25, 0.0);
        glVertex3f(0.75, 0.25, 0.0);
        glVertex3f(0.75, 0.75, 0.0);
        glVertex3f(0.25, 0.75, 0.0);
    glEnd();
    hlEndShape();
    glFlush();
    hlEndFrame();
}
```

The OpenHaptics™ toolkit is easy for graphics programmers to learn and allows significant reuse of existing OpenGL® code.

The **OpenHaptics toolkit includes** the Haptic Device API (HDAPI), the Haptic Library API (HLAPI), utilities, PHANTOM Device Drivers (PDD), and source code examples. The HDAPI provides low-level access to the haptic device, enables haptics programmers to render forces directly, offers control over configuring the runtime behavior of the drivers, and provides convenient utility features and debugging aids. The HLAPI provides high-level haptic rendering and is designed to be familiar to OpenGL® API programmers. It allows significant reuse of existing OpenGL code and greatly simplifies synchronization of the haptics and graphics threads. The PHANTOM Device Drivers support all shipping PHANTOM devices.





The HDAPI provides low-level access to the haptic device, enables haptics programmers to render forces directly, offers control over configuring the runtime behavior of the drivers, and provides convenient utility features and debugging aids.

Key Features and Benefits

- Optimized interface to the SensAble PHANTOM haptic devices, including the low-cost PHANTOM Omni device
- Architected to be extensible and OS platform-independent
- Software control over:
 - User-definable haptic servo loop for ideal performance
 - Error handling and safety limits for an optimal user experience
 - Scheduling user-defined callbacks within the haptic thread for maximum control over synchronization
 - Direct access to encoder values and control over motor DAC values for advanced programming
- Includes API, utilities, and source code examples

Haptic Device API Functionality

Get Device State

- Position, orientation, velocity
- 3 coordinate spaces: Cartesian, joint, raw data I/O (encoder/DAC)
- Buttons

Get Device Characteristics

- Model, version, serial number
- Workspace dimensions, I/O DOF
- Max stiffness, max force, max velocity, max torque, max torque stiffness
- Motor temperature
- Calibration capabilities

Set Device State

- Force/torque in Cartesian space
- Motor DAC
- LED status

Scheduler

- Synchronous and asynchronous user-defined callbacks
- Customizable scheduling of callbacks
- Facilitates synchronization of the haptics and graphics threads
- User-definable haptic servo loop rate

Enable/Disable

- Force: output, clamping, ramping
- Error reporting
- Software checks: max force, max velocity

Error Reporting and Handling

- Error categories, including:
 - Function
 - Force
 - Device
 - Haptic rendering
 - Scheduler
- Error stack

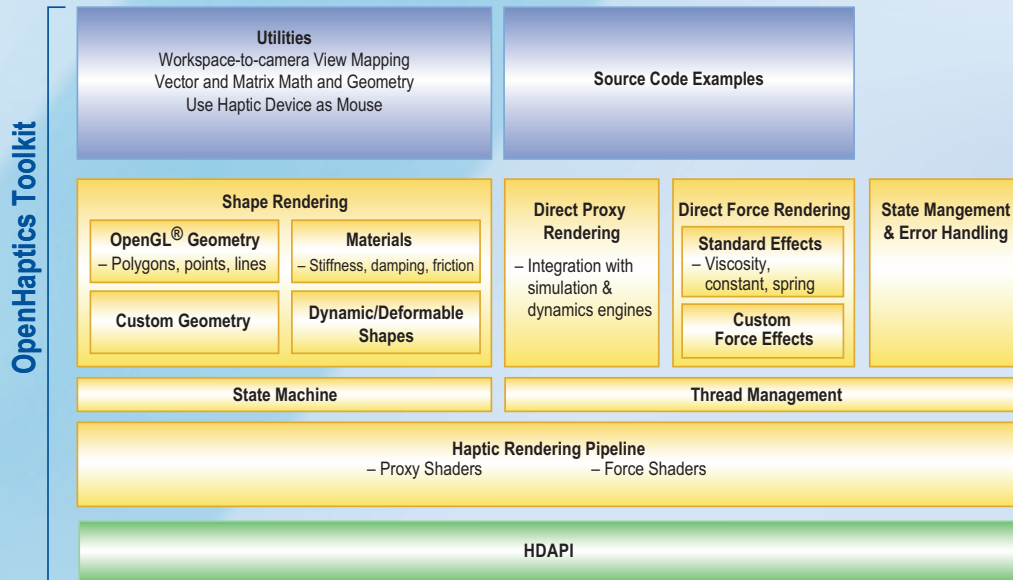
Device Calibration Interface

- Auto calibration
- Manual calibration

Utilities

- C++ haptic device wrapper
- Workspace-to-camera view mapping
- Vector and matrix math and geometry
- Snap constraints

HLAPI—High-level Haptic Rendering



The **HLAPI** provides high-level haptic rendering and is designed to be familiar to OpenGL® API programmers. It allows significant reuse of existing OpenGL code and greatly simplifies synchronization of the haptics and graphics threads.

Key Features and Benefits

- Designed for programmers familiar with graphics and with no prior knowledge of haptics
- Enables reuse of existing OpenGL code for fast integration
- Designed to integrate third-party libraries such as physics/dynamics and collision detection engines
- Extensible and flexible architecture will enable future support of other graphics libraries such as Microsoft® DirectX®
- Support for polygonal meshes, tessellated NURBS, and subdivision surfaces
- Up to 5x faster when optimized for OpenHaptics v2.0*
- Includes API, utilities, and source code examples

Cross-platform support: The Mac® version of OpenHaptics toolkit supports only the PHANTOM Omni device. Haptic Mouse is supported only in the OpenHaptics toolkit for Windows. Detailed specifications and device support may vary by platform.

*Compared to OpenHaptics v1.0, with optimized applications such as HapticExtender™/MX and Haptic Extender/MY

Haptic Library API Functionality

Shapes

- OpenGL primitives (polygons, points, and lines)
- Custom/extension

Force Effects

- Constant (e.g. gravity)
- Viscosity, 3D friction
- Spring
- Custom/extension

Touch Model

- Single point
- Future support for multipoint
- Contact/constraint

Surface Material Properties

- Friction
- Stiffness and damping
- Front/back faces

Dynamics

- Capabilities for integration with third-party physics/dynamics and collision detection engines

Deformable Objects

- Capabilities for third-party integration

Events

- Windows
 - 2D Mouse
- Haptic device
 - Touch/untouch
 - Stylus switch
 - Presence switch
 - Motion
 - Calibration

Programmer Productivity

- Dynamic changes for effects
- Push/pop attributes

SENSABLE Haptic Devices & Toolkits

The Broadest Range of PHANTOM® Haptic Devices & Toolkits for Haptic Application Development



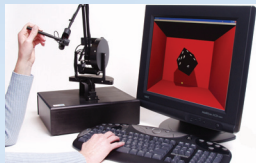
PHANTOM Omni®



PHANTOM® Desktop™



Premium 1.0



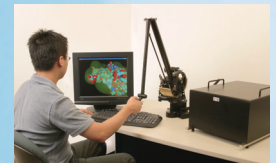
Premium 1.5
Premium 1.5 High Force



Premium 3.0



Premium 1.5/6DOF
Premium 1.5/6DOF High Force



Premium 3.0/6DOF

Haptic Devices

The PHANTOM product line of haptic devices enables users to touch and manipulate virtual objects. Different models in the PHANTOM product line meet the varying needs of commercial software developers, academic and commercial researchers, and product designers. The PHANTOM Premium models are high-precision instruments and, within the PHANTOM product line, provide the largest workspaces and highest forces, and some offer 6 degrees of freedom (6DOF) output capabilities. The PHANTOM Desktop and PHANTOM Omni devices offer affordable desktop solutions. Of the two devices, the PHANTOM Desktop delivers higher fidelity, stronger forces, and lower friction, while the PHANTOM Omni is our lowest-priced haptic device available.

OpenHaptics Toolkit

The Open Haptics toolkit enables software developers to add haptics and true 3D navigation to a broad range of applications, from design to games and entertainment to scientific visualization. The OpenHaptics toolkit is patterned after the OpenGL® API, making it familiar to graphics programmers and facilitating integration with new or existing OpenGL applications. This haptics toolkit handles complex calculations, provides low-level device control for advanced developers, and supports polygonal objects, material properties, and force effects. The OpenHaptics toolkit supports a range of PHANTOM devices from the low-cost PHANTOM Omni device to the larger PHANTOM Premium devices.

Customers

Selected haptic application development customers include Boeing, CSIRO, General Electric, KAIST, MIT, NTT Research Lab, RIKEN, Sandia National Labs, Stanford University, Tokyo University, University of Glasgow, University of Hong Kong, University of North Carolina, and University of Siena.

For more information, visit www.sensable.com.

About SensAble Technologies

SensAble Technologies provides software and devices that add the sense of touch to the digital world, including 3D touch-enabled modeling systems and the PHANTOM® line of haptic devices and OpenHaptics® toolkit. SensAble modeling systems are used for product design, medical and dental modeling, digital content creation, and fine arts. The PHANTOM force-feedback devices, which enable users to touch and manipulate virtual objects, and the developer toolkit, are used for simulation and training, robotics, and third-party development. In addition to off-the-shelf solutions, SensAble offers contract development to OEMs for new and customized software applications and haptic devices. SensAble maintains headquarters in the United States and a sales office in Japan. SensAble products are available through direct and reseller channels.

Product specifications are for the OpenHaptics toolkit v2.0 and are subject to change without notice.



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