

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 an element of fun to your application.

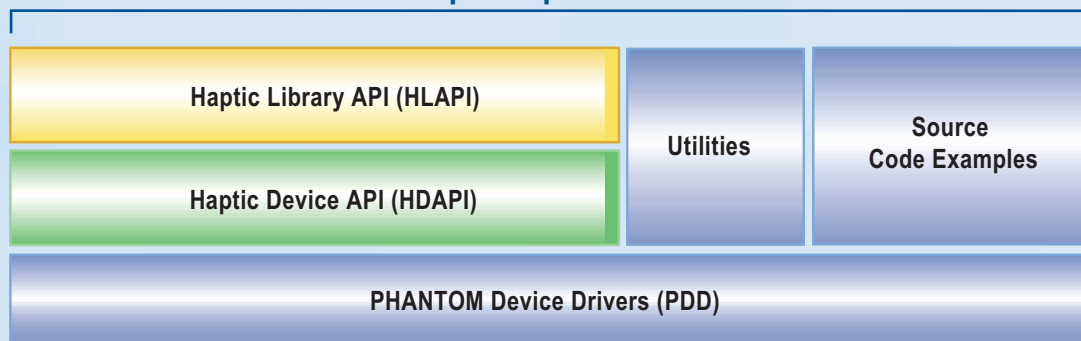
The **OpenHaptics™ toolkit** enables software developers to add haptics and true 3D navigation to a broad range of applications, including 3D design and modeling, medical, games, entertainment, visualization, and simulation. This haptics toolkit is patterned after the OpenGL® API, making it familiar 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 current version of the toolkit supports Microsoft® Windows® XP and 2000. Future support for the Linux® and Macintosh® platforms is planned.

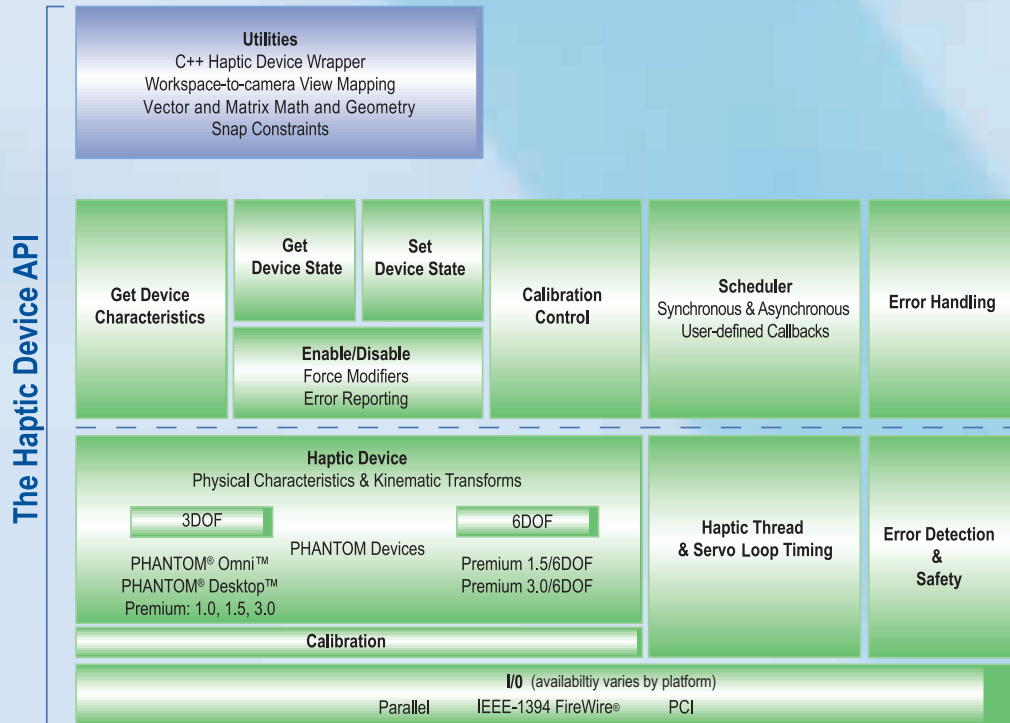
```
// display method for "HelloHaptics" program
void display(void)
{
    hlBeginFrame();
    glClear(GL_COLOR_BUFFER_BIT | GL_DEPTH_BUFFER_BIT);
    glColor3f(1.0, 0.0, 0.0);
    hlBeginShape(HL_SHAPE_DEPTH_BUFFER, myShapeId);
    glBegin(GL_POLYGON);
        glVertex3f(0.25, 0.25, 0.0);
        glVertex3f(0.75,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





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
- Motor temperature
- Calibration capabilities

Set Device State

- Force/torque in Cartesian space
- Motor DAC

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

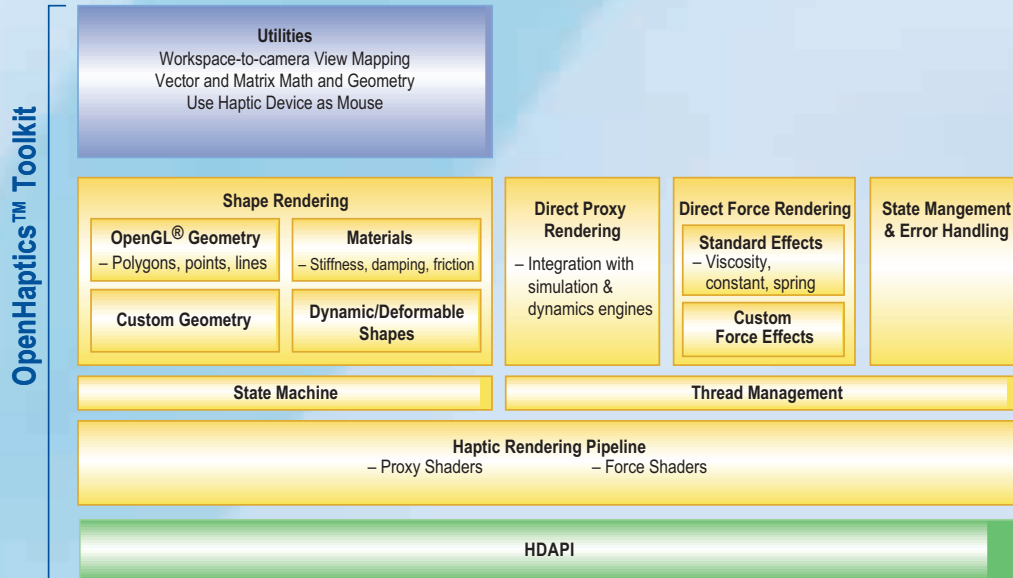
- Error categories, including:
 - Function
 - Force
 - Device
 - Haptic rendering
 - Scheduler
- Error stack

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



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 and therefore tessellated NURBS and subdivision surfaces
- Includes API, utilities, and source code examples

OpenHaptics API Features

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

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

Deformable Objects

- Hooks for third-party integration

Events

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

SENSABLE Haptic Devices & Toolkits

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



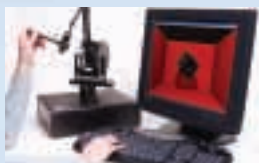
PHANTOM® Omni™



PHANTOM® Desktop™



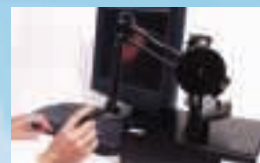
Premium 1.0



Premium 1.5



Premium 3.0



Premium 1.5/6DOF



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) 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 the most cost-effective haptic device available.

Toolkits

The OpenHaptics 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.

The GHOST SDK is designed for developers who have haptics knowledge and expertise and who need an SDK with a built-in scene graph. Developers can use the libraries of 3D prismatic objects, polygonal objects, and force effects within the GHOST SDK to add a convincing physical dimension to a variety of applications. The GHOST SDK supports a range of PHANTOM devices from the PHANTOM Desktop device to the larger PHANTOM Premium devices.

For more information, visit www.sensable.com.

About SensAble Technologies

SensAble Technologies, Inc® is a leading provider of 3D touch-enabled digital solutions for commercial software development, academic and commercial research, and product design. Haptic application development customers include Boeing, CSIRO, General Electric, KAIST, MIT, NTT Research Lab, Sandia National Labs, Tokyo University, University of Glasgow, University of Hong Kong, University of North Carolina, and University of Siena. The SensAble FreeForm® systems are used for 3D product design by leading companies in diverse industries including education, footwear, giftware/collectibles, household goods, jewelry, medical, packaging, sporting goods, and toys. SensAble has its headquarters in the United States and sales offices in Europe and the Asia/Pacific region. SensAble products may be purchased through direct and reseller channels.

Product specifications are for the OpenHaptics toolkit v1.0 and are subject to change without notice.

© 2004 SensAble Technologies, Inc. All rights reserved. FreeForm, FreeForm Concept, FreeForm Modeling, FreeForm Modeling Plus, FreeForm Mold, GHOST, HapticSound, OpenHaptics, PHANTOM, PHANTOM Desktop, PHANTOM Omni, 3D Touch, Splodge, SensAble, and SensAble Technologies, Inc. are trademarks or registered trademarks of SensAble Technologies, Inc. Other brand and product names are trademarks of their respective holders.



www.sensable.com

Corporate Headquarters

SensAble Technologies, Inc.
15 Constitution Way
Woburn, MA 01801 USA
[t] +1-781-937-8315
[f] +1-781-937-8325

Europe

SensAble Technologies GmbH
Curierstraße 2, D-70563
Stuttgart, Germany
[t] + 49 (0)711 67400205
[f] + 49 (0)711 67400491

Japan

SensAble Technologies, Inc.
BCY 11F Yurakucho Bldg.
1-10-1 Yurakucho, Chiyoda-ku, Tokyo,
100-0006, Japan
[t] +81-3-5219-2027
[f] +81-3-5219-2021

China

SensAble Technologies, Inc.
Suite 1801-21, 18F Shanghai Oriental Centre
699 Nanjing West Road (formerly 31 Wujiang Road)
Shanghai 200041, China
[t] (+8621) 3210 0763
[f] (+8621) 5211 0177