User Manual

HFD-6 Haptic Device

Version 1.6.1

2024.10

Overview

The purpose of this manual is to：

- Describe the setup steps for the HFD-6 Haptic Device
- Describe the installation process for device drivers
- Describe the operating methods for the HFD-6 Haptic Device

Key Terms

HFD_API: Dynamic Linked Library provided by the HFD-6 device

HFD-6:　6-DOF Hybrid Force Feedback Device

HFD_Test：Software provided for HFD-6 device calibration and testing

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1. Device Description

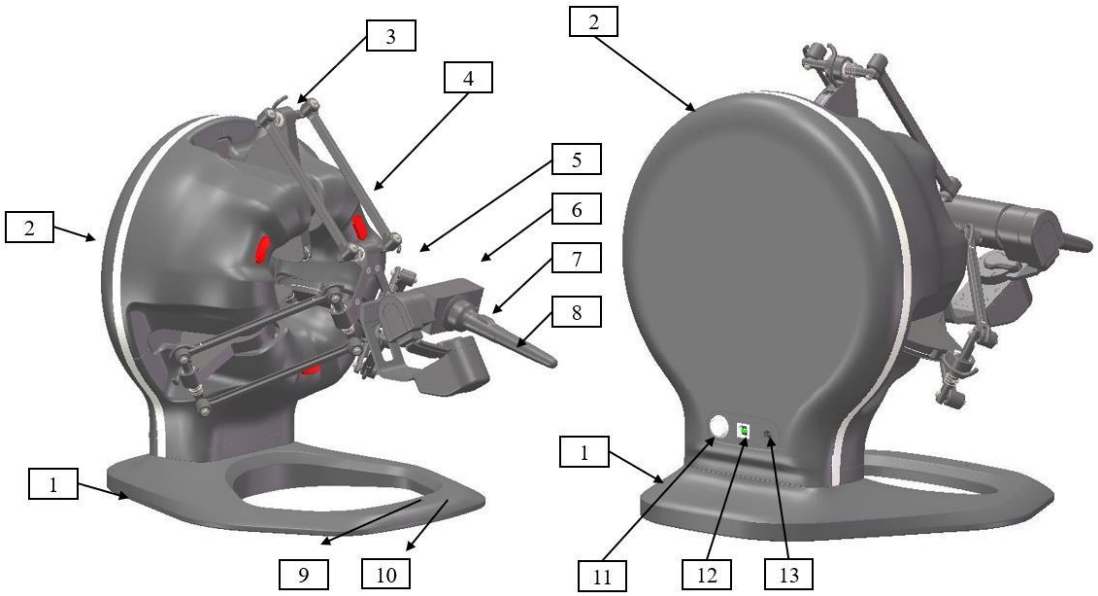

Figure1 Device Components

1. Base
2. Controller
3. Semi-Circular Active Rod
4. Passive Rod
5. Floating Platform
6. End-Effector
7. Programmable Button
8. Handle
9. Power Indicator
10. Device Enable Indicator
11. Power Switch
12. USB Port
13. Power Port

2.Safety Precautions

IMPORTANT

WHEN USING THIS UNIT, BASIC SAFETY PRECAUTIONS SHOULD ALWAYS BE FOLLOWED TO REDUCE THE RISK OF FIRE, ELECTRICAL SHOCK, OR PERSONAL INJURY

1. Read and understand all terms carefully.

2. Comply with all precautions and instructions marked in this manual

3. Place the device on a stable desk away from water sources.

4. Ensure no obstacles are within the device's motion range.

5. Turn off the power when not in use.

6. Do not disassemble the device to avoid electric shock

3. Setting Up the HFD-6 Device

IMPORTANT

PLEASE KEEP THE ORIGINAL PACKAGING
ONLY USE THE ORIGNAL PACKAGE FOR STORING OR SHIPPING

3.1 Unpacking the Device

Before removing the HFD-6 from its packing, first remove the foam fixators and accessories.

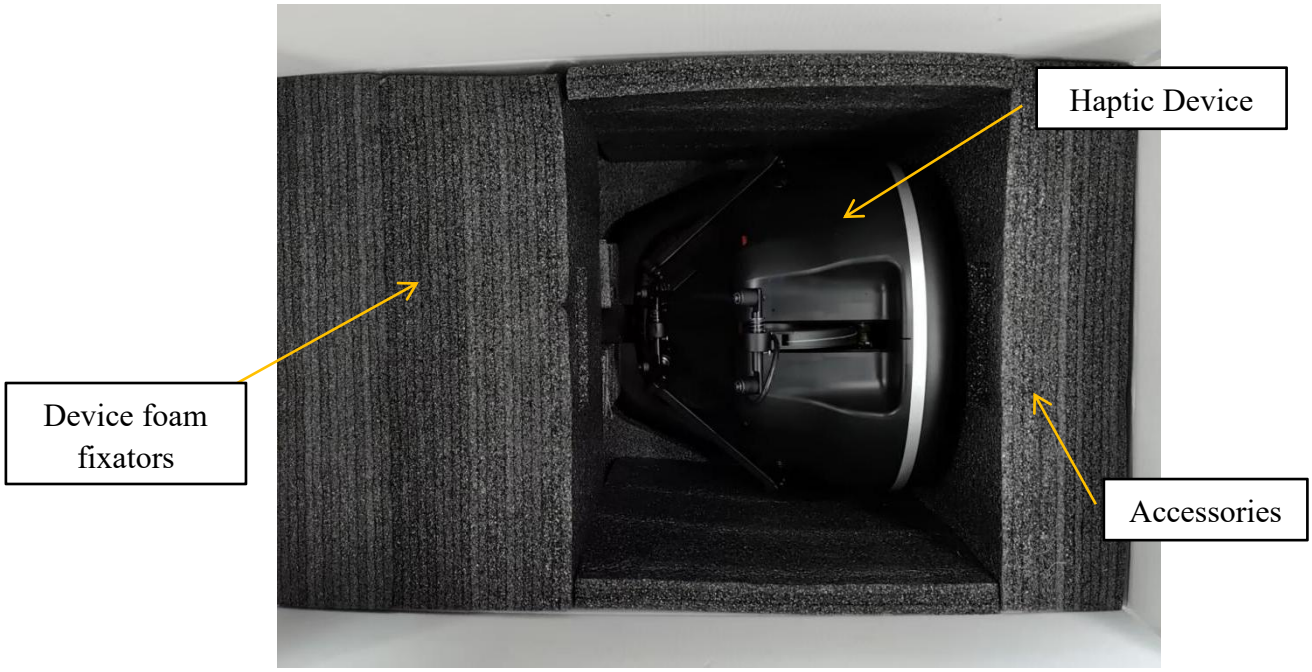

Figure 2 Packaging Overview

Carefully remove the device and accessories from the foam fixators.

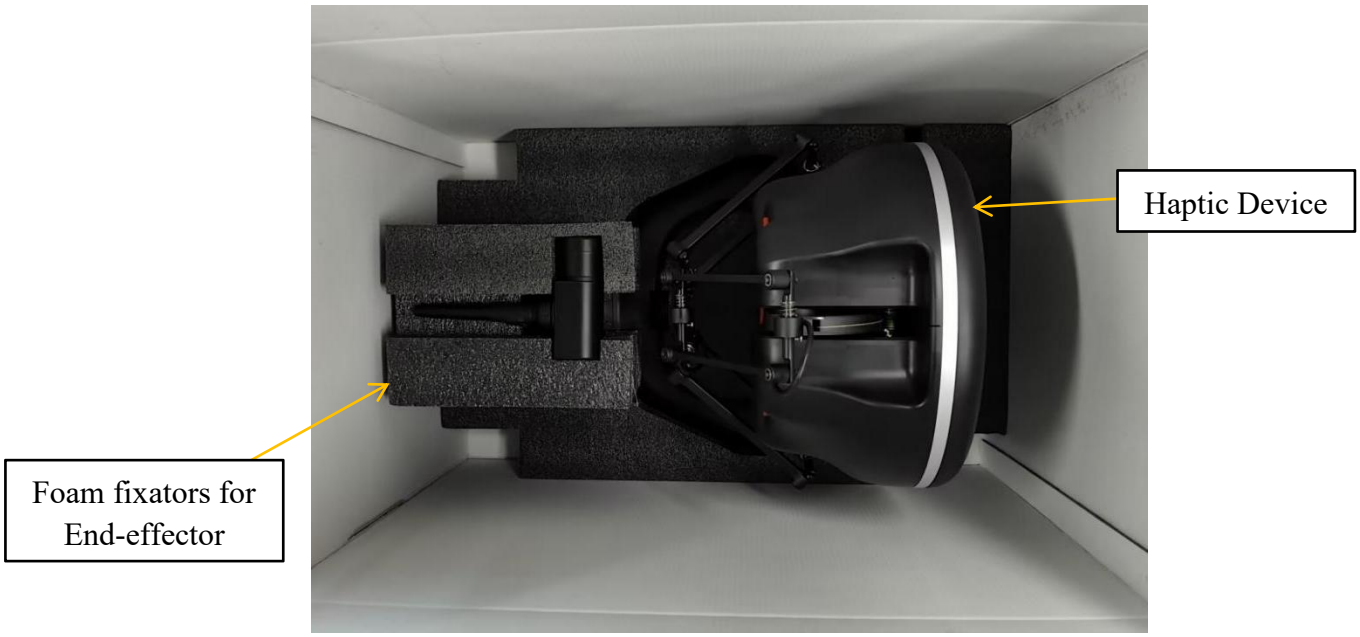

Figure 3 Packaging Overview after removing foam fixators and accessories

The package includes Power cable, USB cable, U Disk(containing drivers, test software, and documentation), and Power adapter.

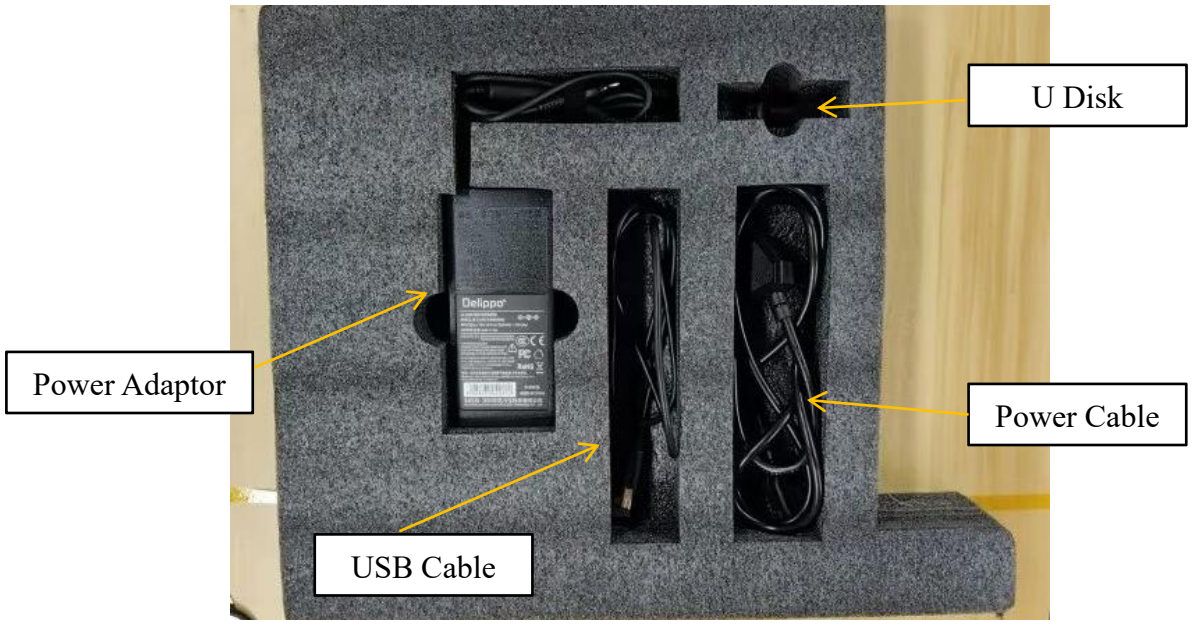

Figure 4 Device Accessories

3.2 Power Connection

Insert the power cable into the adapter. The HFD-6 supports 220V AC. Use only the included power adapter.

4. File Description

The U Disk includes the following folders：

1.Documentation：

- HFD-6 User Manual
- HFD_Test Software Guide
- HFD_API Dynamic Link Library Guide
- gult Configuration Guide
- iMSTK Integration Guide
- SOFA Integration Guide
- HFDTech3D_Unity_Plugin User Manual
- Solution of Device identification Problem

2 USB Driver：

- VCP_V1.3.1_Setup.exe
- VCP_V1.3.1_Setup_x64.exe

3 Control Software：

- HFD_Test_win，control software on windows，including Debug and Release configuration on Win32，x64 platform
- HFD_Test_linux control software on Linux, including Debug and Release configuration

4 Example Programs：

- HFD Example_win(Windows)
- HFD Example_linux(Linux)

5 Header Files：

- HFD_OPEN.h
- hfdDefines.h
- hfdVector.h
- hfdVector.inl

6 Library Files:：

- Windows：.dll(32/64-bit)
- Linux：.a(static)/.so(dynamic)

7：glut Installation:

- Header file：glut.h　　lib file：glut.dll　　glut configuration guides

8：Unity3D Plugin：

- HFDTech3D.unitypackage
- HFDTech3D_Unity_Plugin User Manual

9：External Module：

- HFDTech3D CMake project files
- ROS Project
- SOFA　CMake project files of linking HFD-6

10：Demo：

- Chai3D_Demo
- iMSTK_Demo
- SOFA_Demo
- Unity_Demo

5. Configuring the HFD-6 on Windows

5.1 Driver Installation

1.Insert the U disk and navigate to **USB Drivers**;

2.Run **VCP_V1.3.1_Setup.exe**;

3.Follow on-screen instructions to complete installation;

4.Power on the device and wait **5 seconds** before launching software;

6. Configuring the HFD-6 on Linux

On Linux systems(taking Ubuntu as an example), there is no need to install special drivers. After connecting the device to the system with a USB cable, it will be recognized as a **ttyACM*** file(**specially, in Linux systems, it is often necessary to use the chmod command to unlock the read and write permissions of ttyACM* before calling the device program for related operations, that is sudo chmod 777 ttyACM***).

Copy **3_Control Software-->Linux-->HFD_Test_linux** file to ubuntu system，on the Terninate，run the control program：sudo ./HFD_Test.

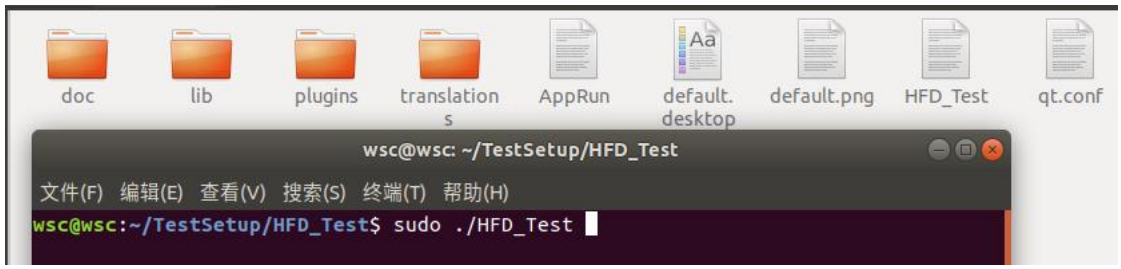

Figure 5 run the control program on ubuntu

Enter the system password to launch the program.

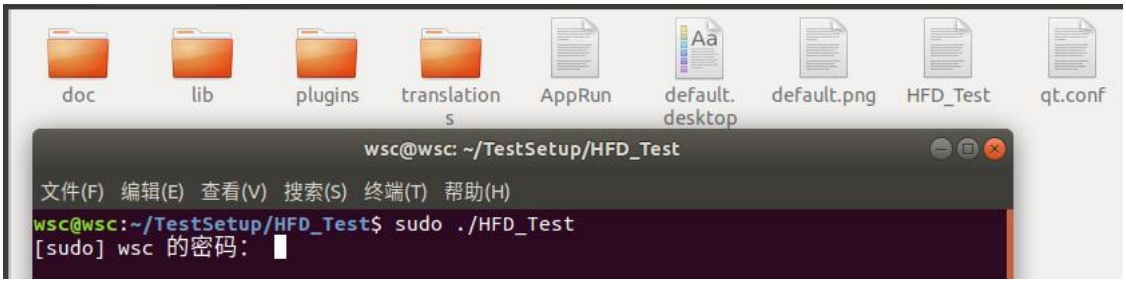

Figure 6 Enter system password

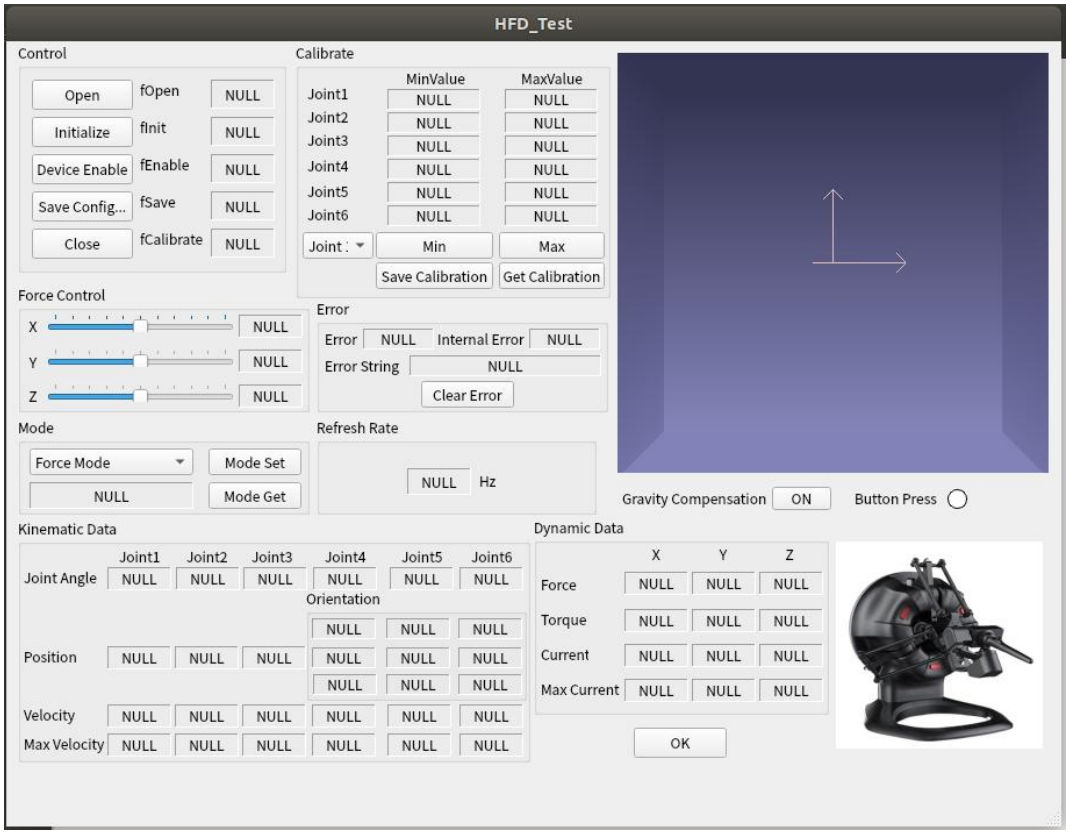

Figure 7 Control software Interface on ubuntu

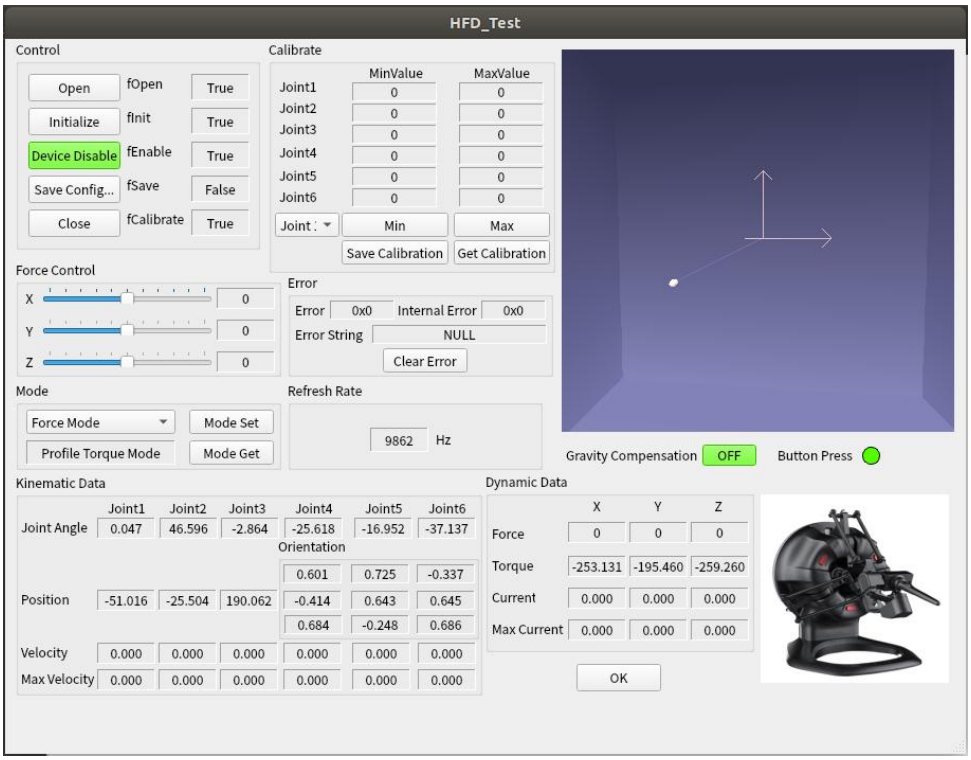

Figure 8 Operate the control software on ubuntu

7. Using the HFD-6

7.1 Coordinate System

The HFD-6 Haptic device has 6 DoFs(3 translation ,3 rotation),the3 translational DOF is constructed by Delta parallel mechanism, the 3 rotational DoF are Yaw, Pitch and Roll. Joint 1, 2, 3 have the minimum angle value when three semi-circular rotate to forefront, and have the maximum value in the rearmost. Joint 4 has the minimum angle value when it rotates to the rightmost, and has the maximum one when it rotates to the leftmost. Joint 5 has the minimum angle value in the bottom and maximum value in the top. Joint 6 has the minimum angle value when the handle rotates counterclockwise to the extreme and has maximum value in the clockwise extreme. The Position and Posture of HFD-6 can be obtained from the controller. Controller converts encoder values to Position(X,Y,Z) and rotational matrix(3x3) in Cartesian Coordinate system. The minimum and maximum value of encoder can be checked in the control software when calibrating the device.

Figure 9 Coordinate System

The base coordinate origin is the center of a triangle formed by the centers of the three semi-circular disks. The intersection point of the rotational axes of joint 4,5 and 6 is the origin of the end coordinate system. The 3x3 attitude matrix is the expression of the posture of the end coordinate system after rotating (oa, ob, og) around the Y-axis, X-axis, and Z-axis in sequence. Assuming the initial homogeneous matrix of the end coordinate system pose is X_0 and the time translation matrix is T, then the homogeneous matrix of the time end coordinate system pose is $X_t = R_t * X_0 + T$.

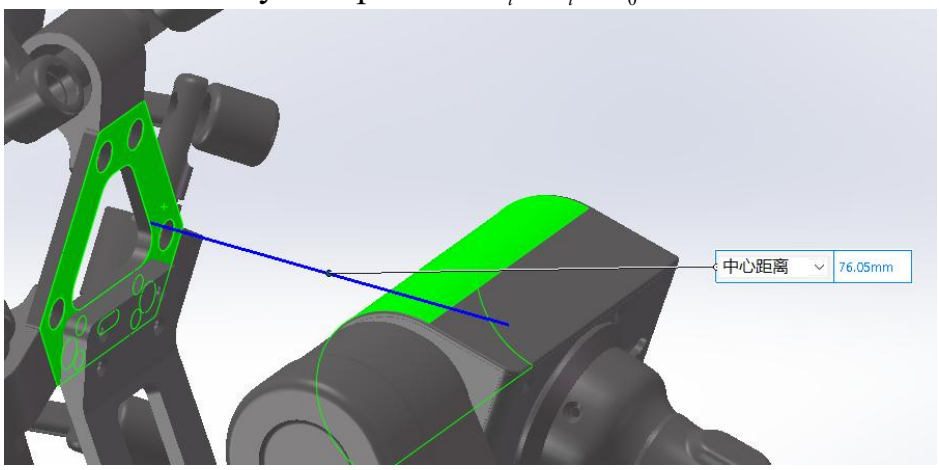

Figure 10 Schematic diagram of center distance

7.2 Using HFD-6

7.2.1 LED Indicators

The HFD-6 device has two LED indicator lights, white and green.

White LED -- not yet enabled

Green LED on -- device enabled, can output feedback force

Green LED off -- the device is disabled and unable to output feedback force

7.2.2 Device Features

◆**Calibration :** The purpose of calibration is to obtain a more accurate position and posture of the end effector in the device's motion space. The HFD-6 Haptic device uses absolute encoders, and the calibration information of the device is saved in the device at the factory. It can be

used directly after power on without calibration. But sometimes in order to prevent drift of encoder data during equipment handling. After powering on, use HFD_Test software to recalibrate and click【Save Calibration】to save the calibration information back to the device. During the operation of HFD-6 equipment, the calibration data is always valid. Therefore, after power on, only one calibration needs to be completed to obtain accurate equipment position and posture.

◆**Gravity Compensation :** To prevent user fatigue and increase accuracy during the operation process. The HFD-6 Haptic device has gravity compensation. When the gravity compensation is activated, the weight of the end effector and rod can be dynamically compensated in the workspace. Note that gravity compensation is a special form of force feedback output, so gravity compensation can only be activated after the device is enabled. Gravity compensation can be dynamically enabled and disabled in the program through the API interface provided in HFD_API. If the user finds that the gravity compensation effect is not good during use, please recalibrate according to the above【Calibration】instructions.

◆**Force Feedback :** By default, when the device is turned on, the feedback force output function is turned off. Users can dynamically turn on and off the force feedback output in the program through the API interface provided in HFD_API.

◆**Electromagnetic Braking :** The HFD-6 Haptic device has an electromagnetic braking mechanism. When the device speed is too fast, in order to prevent damage to the device and the user, the device automatically activates the electromagnetic braking, causing the device to enter a viscous damping state. At this time, the force feedback output function is turned off. In addition, users can dynamically turn on and off

the braking function in the program through the API interface provided in HFD_API.

7.3 Run HFD_Test Control Software

The HFD_Test control software is used for testing and diagnosing for HFD-6.

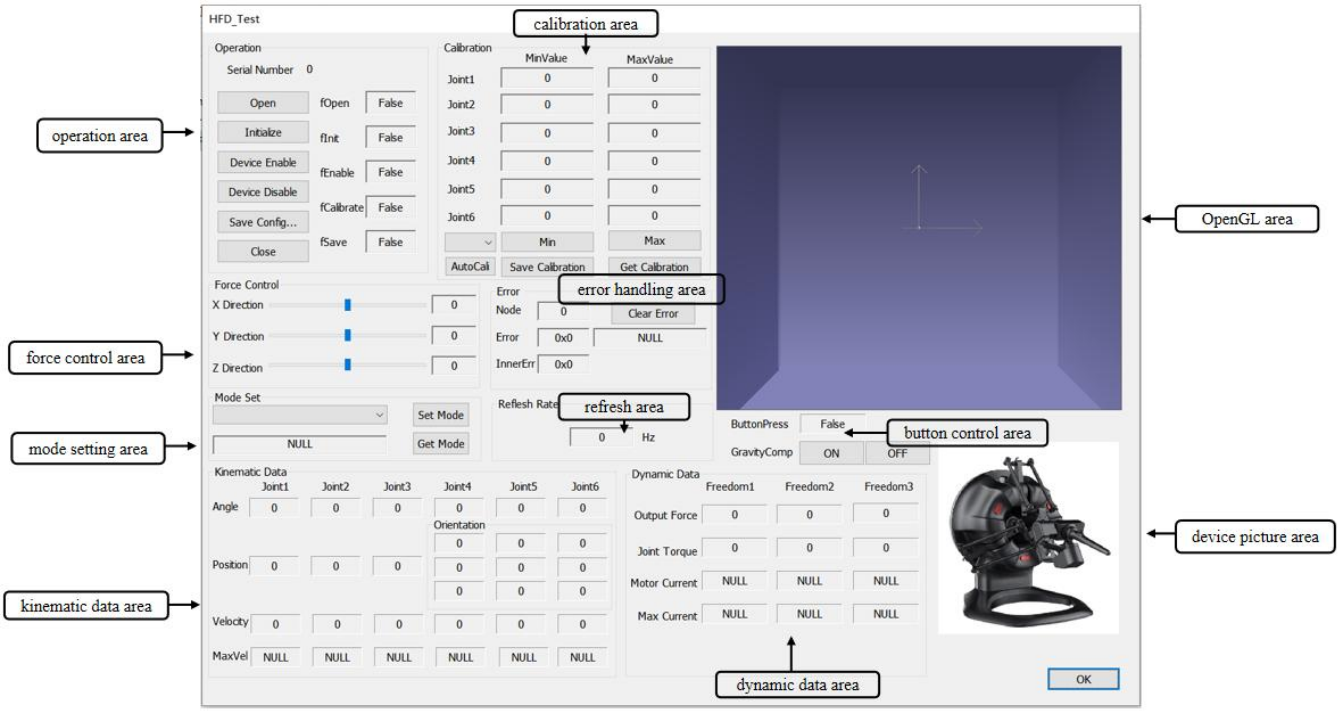

Figure 11 HFD_Test Control Software

Functions include：

- Device open/close、initialize、enable/disable device；
- Joint calibration and data saving；
- Set up operation mode；
- Force feedback control(X/Y/Z axes)；
- Refresh rate testing；
- Gravity compensation testing；
- Kinematic and Dynamic data checking；

7.4 Demo Programs

The HFD_6 Haptic device has been connected to some third-party open source dynamic simulation library like Chai3D/iMSTK/SOFA, and all display programs in these open source libraries can be explored through the HFD_6 device.

In the installation directory of the Chai3D open source library, find the directory where the bin executable file is located, which is \ chai3d-3.2.0-multiform\chai3d-3.2.0\bin\winWin32. Double click the. exe file to run the corresponding display program.

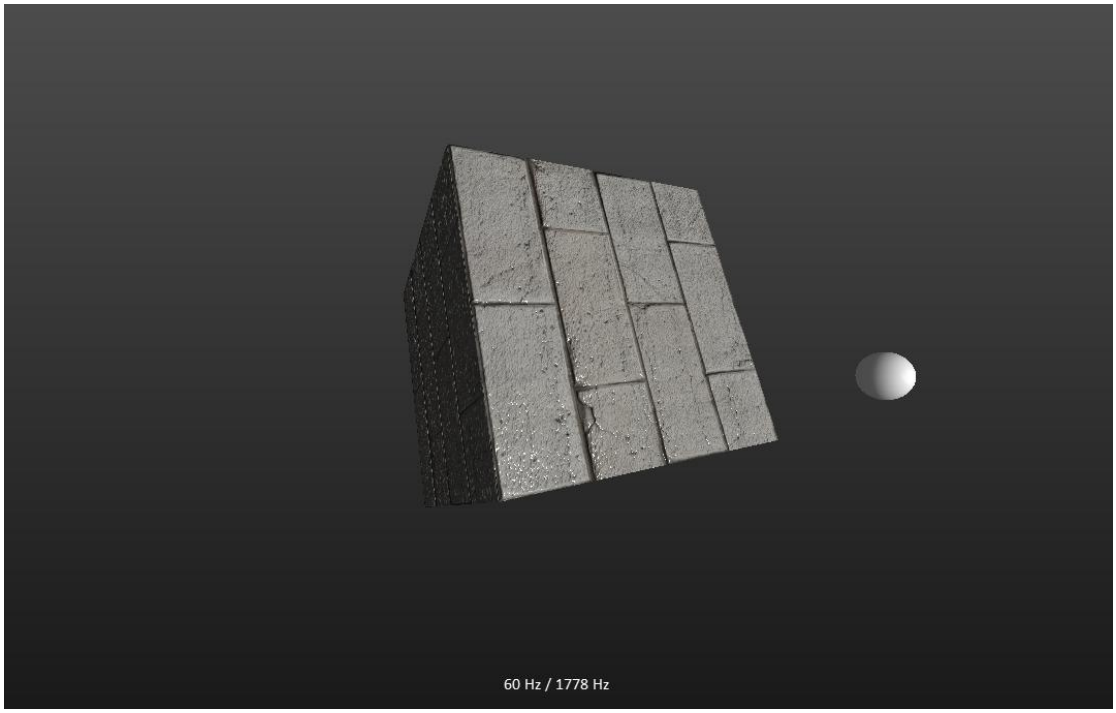

Figure 12 Chai3D Demo

Attention: The HFD_Test control software and the third-party open source dynamic simulation library Chai3D display program require the installation of OpenGL Utility Toolkit (GLUT). Please refer to the USB flash drive shipped with the device or the reference link for the installation file and installation method of GLUT：http://www.opengl.org/resources/libraries/glut.html

8. Technical Specifications

Workspace	Translation	210*210*130 mm	
	Rotation	240*115*320 deg	
Force	Continuous Force	8.5 N	
Resolution	Linear	0.02mm	
	Angular	0.005 deg	
Stiffness		7.8 N/mm	
Interface	Standard	USB2.0	
	Refresh rate	4KHz	
	Power	220V AC to 24V DC	
OS Support	Microsoft	Windows 7/8/10/11	
	Linux	All distributions	
SDK	Device layer	Windows	HFD_API.dll、HFDTech3D.dll
		Linux	HFD_API.so
	Application Layer	Unity3D	HFDTech3D.cs
Structure	A parallel mechanism based on Delta, decoupled from the end series rotating mechanism, with passive and active dual force compensation function		
Calibration	Absolute encoders; auto-calibration on startup		
User Input	1 programmable button on the end-effector		
Safety	Electromagnetic braking for overspeed protection		