Hand Model Calibration

1 Prerequisites

1.1 Glove and Fit

Table 1

Item	Requirement
Sensor attachment	The glove and each sensor must stay in the same relative position during calibration and in later use.
Fit	The glove fits snugly and does not slip. If it slips, secure it again before you calibrate.
Data status	Data from all five fingers is valid, and confidence stays consistently above the threshold. If you use the wrist receiver, its data must also be valid and stable.
Range of motion	Leave enough room to fully bend and straighten the four fingers and to touch each fingertip to the thumb.

1.2 Software and Environment

- Use the official release of the algorithm application that matches your glove. Do not mix calibration files from different versions.
- Make sure the calibration state folder is writable. By default, it is in the local user data area. To use a different folder, set the `GLOVE_KINEMATICS_STATE_DIR` environment variable.
- By default, raw data is sent over UDP to `127.0.0.1:12345`, and processed data is published on port `23456`. The two ports must be different.
- Remove sources of electromagnetic tracking interference. Make sure nothing bumps into or blocks the wearer's hand during calibration.

1.3 Wearers and Hand Side

- Each calibration session handles one hand. The hand side is determined by the hand side information carried in the data stream.

- Upstream, send only the data stream of the hand you are calibrating.
- Each hand of each wearer has its own calibration. Calibrations cannot be shared.

2 Calibration Procedure

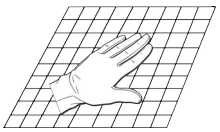
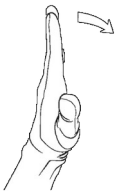
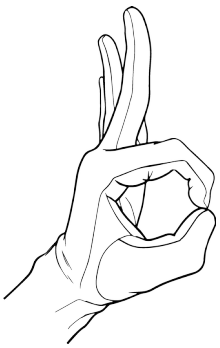
2.1 Overview

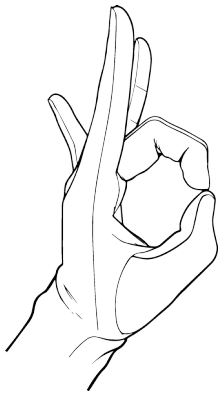
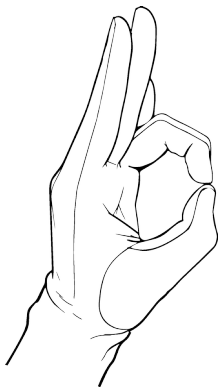
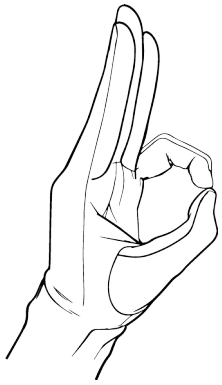
Start the algorithm application in calibration mode. The wearer then completes the following poses by following the on-screen instructions (displayed in Chinese). The system evaluates every pose automatically.

```
Waiting for data stream → Zero pose → Four-finger flexion → Thumb-to-finger opposition (four fingers in turn) → Automatic processing → Activation → Live operation
```

2.2 Pose Guidelines

Table 2

Step	Illustration	Motion	Key Points
1		Flat	Straighten your fingers naturally and hold still. Avoid tensing, shaking, or visibly bending your fingers.
2		Four fingers flexion	Starting with your four fingers straight, bend them toward your palm at the base joints, then straighten them again. Do this twice in a row. Keep the other finger joints as straight as you can, and keep your palm and wrist still.
3		Thumb–Index Opposition	Lightly touch the pad of your index finger with the pad of your thumb and hold steady.

Step	Illustration	Motion	Key Points
4		Thumb–Middle Opposition	Fully release the previous pair, then lightly touch the pad of your middle finger.
5		Thumb–Ring Opposition	After fully releasing, touch lightly when the **next instruction** appears. Avoid touching other fingers at the same time.
6		Thumb–Little Opposition	Touch fingertips naturally as shown, and hold steady without pressing.

General requirements:

- Each pose starts with a countdown of about 1 second. Begin the pose after the countdown ends.
- Stay natural and relaxed throughout. Do not use force. When your fingers touch, do not squeeze or rub them.
- After each opposition pose, release completely and spread all five fingers apart. Start the next pose only after the prompt for the next finger appears.
- The system checks every pose automatically. If a pose does not pass, the system asks you to repeat it. You do not need to judge it yourself.

- The wearer only needs to follow the on-screen instructions and the live feedback (distance, hold time, and so on) to adjust each pose.

2.3 Progress and Feedback

During calibration, the screen shows the current stage, pose instructions, data status, and number of failures. Contact poses also show live distance and hold time. The system retries failed poses automatically. If the same pose fails 3 times in a row, calibration pauses and waits for a manual command (see Section 5.1).

2.4 Completion and Activation

Calibration has succeeded only when the screen shows CALIBRATION_ACCEPTED.

If CALIBRATION_ACCEPTED does not appear, the calibration has not taken effect. Calibrate again.

2.5 Output Files and Custom Hand Shapes

Each successful calibration generates a calibration URDF file, saved in the calibration output area of the user data folder, with left and right hands stored separately. Writing includes verification and rollback, so existing files cannot be corrupted.

For hands with unusual shapes, a specialist can edit the personal geometry configuration file and then recalibrate. After you modify the base model or joint parameters, you must recalibrate.

2.6 Glove URDF Example

The following is a visualization of the default URDF:

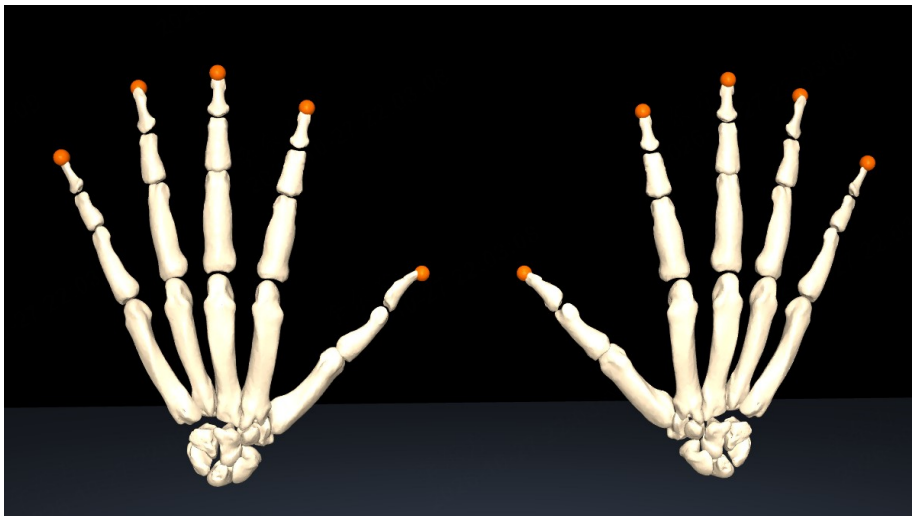


Figure 1

3 Verify the Results

Calibration passes only when both conditions are met: the screen shows the activation message (Section 2.4), and the manual checks in the table below find no issues. The system checks data quality and calibration results automatically during calibration, and activates the calibration only after all checks pass.

3.1 Acceptance Checks

Table 3

Check	Action	Pass Criteria
Joints	Return to the zero pose, then slowly bend and straighten the four fingers.	The visualized hand matches the real hand. Joint angles are smooth, with no abnormal spreading.
Fingertips	Lightly touch each fingertip to the thumb in turn.	The model fingertips actually touch, as the real fingertips do, without gaps or overlap.
Skeleton	Spread all five fingers, then make a fist.	Each finger segment matches the real hand in length, with no stretching or misalignment.
Wrist	Rest the wrist flat naturally (when a wrist receiver is configured).	Wrist orientation output is non-null and stable. If the output is null, see Section 5.2.

Also check that the teleoperation receiver continuously outputs frame numbers and joint angles. Frame numbers may skip but must never go backward.

3.2 Keep Records

- If an acceptance check is in doubt or calibration behaves abnormally, save a diagnostic file in the paused state and archive it with the work order.
- If you need to reproduce an issue, record raw data, processed results, and metadata at the same time, and archive the three together.
- For formal acceptance, run an offline reprocessing regression on the recorded data. If processing fails on any frame, acceptance fails.

4 When to Recalibrate

Recalibrate if any of the following occurs:

Table 4

Trigger	Description
Change of wearer, glove, or sensor	Calibration results cannot be shared.
Change in sensor position or direction, or the glove slips	Secure the glove and sensors again before you calibrate.
Model, firmware, or protocol upgrade	The system rejects the old calibration. This is an intended safeguard.
Active calibration damaged or missing	The system reports an error at startup and asks you to calibrate.

Guidelines:

- If you only restart the program and the glove and sensors have not changed, you do not need to recalibrate.
- If calibration results are poor, the system does not silently fall back to the generic model. You must recalibrate.
- If you are unsure, first run the fingertip check in Section 3.1. If opposition is clearly inaccurate, recalibrate.

5 Troubleshooting

5.1 Commands in the Paused State

After a calibration pose fails 3 times in a row, calibration pauses. The following commands are available:

Table 5

Command	Function
r	Retry the current pose
b	Go back to the previous pose. Data captured after it is discarded.
l <path>	Check an existing calibration file (check only; it is not activated).
d <path> / q	Save a diagnostic file and exit.

5.2 Common Issues

Table 6

Issue	Solution
Stuck at "Waiting for data stream", with a delay or disconnection message	Check that upstream sends only the hand being calibrated, and that the address and port are correct. When data resumes, the current pose restarts automatically.
Data quality stays low	Check the fit and sensor attachment, and remove interference sources. The confidence threshold cannot be lowered.
Zero pose or flexion keeps restarting	Relax, slow down, and increase your range of motion as instructed. Adjust based on the on-screen feedback.
Opposition shows "Waiting for separation", or holds keep breaking	Spread all five fingers fully before you bring them together. Touch naturally without squeezing.
The system asks you to redo one finger or all opposition poses	Redo them as instructed. If they keep failing, check whether the sensor on that finger is loose.

Issue	Solution
"Calibration activation failed"	Make sure no other calibration process is running and that storage is writable, then try again. If it still fails, save a diagnostic file and report it.
Error at startup, asking for calibration	Both the active and backup calibrations are missing or invalid. Recalibrate, or restore as described in Section 7.
Incompatibility error on loading	This is an intended safeguard. Recalibrate as instructed. Do not edit calibration files manually.
Wrist orientation output is null	No wrist receiver is configured, or the wrist zero pose did not pass. If you need wrist output, check how the wrist receiver is worn, then recalibrate.

5.3 Escalation Path

The operator first checks the issue by following the on-screen instructions. If the issue remains, save a diagnostic file, then send it to Technical Support along with the calibration file path and recorded data.

6 Calibrate with the SDK Toolchain

This chapter continues from Chapter 9 of the **OmniGlove SDK User Guide**. **SDK toolchain calibration and the algorithm application calibration in Chapters 1–5 are two independent mechanisms.** The algorithm application produces a calibration URDF through the guided on-screen procedure in Chapter 2. The SDK toolchain uses Linux command-line tools to capture data, fit the model, save a candidate, and deploy it to the device. Output from one cannot be used by the other.

6.1 Tools and Prerequisites

On Linux, `omniglove_calibration_tool` captures the six poses, fits the model, saves the candidate, and activates it. `omniglove_bone_deploy_tool` deploys a saved candidate to the matching device. The public C API provides calibration blob/phase control and BONE read/write. See Chapter 8 of the **OmniGlove SDK User Guide**.

1. Install the SDK for your architecture and the udev rules, then unplug and reconnect the glove.

2. Close other programs that use the device, and make sure exactly one device initializes successfully.
3. Put on the glove correctly, keep power and the connection stable, and prepare a work folder that the current user can write to.
4. Run the tools as a regular user and follow the terminal instructions. Do not use sudo.

6.2 Capture the Six Poses

Start from the Linux platform folder:

```
./bin/omniglove_calibration_tool --work-dir ./calibration-output
```

Table 7

Stage	Pose and Check
Zero pose	Hold the flat zero pose steady as guided.
Four-finger pose	Bend and straighten the four fingers together twice.
Thumb opposition 1	Touch the thumb to the index finger.
Thumb opposition 2	Touch the thumb to the middle finger.
Thumb opposition 3	Touch the thumb to the ring finger.
Thumb opposition 4	Touch the thumb to the fifth finger.

The CLI shows pose progress and quality feedback. A stream interruption, sequence gap, low confidence, wrong pose, or too much movement invalidates the current continuous window. Repeat the current pose as guided.

6.3 Output Files and Quality Checks

By default, publish=save saves the candidate on the host and switches the active manifest, without writing to the device. Activating a candidate on the host does not mean BONE on the device has been updated. Use a separate work folder for each calibration, and keep the capture, candidate, manifest, and full terminal output.

Table 8

Item	Current Specification
capture artifact schema	v2

Item	Current Specification
candidate schema	v3
Coordinate conventions	right-handed TX；positions converted from mm to m；orientation as ZYX yaw/pitch/roll
Zero pose p95 threshold, five-finger position / orientation	3 mm／3°
Frame-to-frame p95 threshold, position / orientation	1.6 mm／2°
Wrist orientation p95 threshold	3°

The values in the table are the quality thresholds of the current tool. Before you deploy, check the candidate schema, device identity, and hand side. Older schemas are not processed as the current writable format.

6.4 Write Now or Deploy Later

To write to the device right after saving, explicitly select `save-and-device`:

```
./bin/omniglove_calibration_tool \
  --work-dir ./calibration-output \
  --publish save-and-device
```

The tool first saves the candidate on the host, then encodes and writes `BONE v4`, and finally reads back the full data and compares it byte by byte.

To deploy a saved candidate later:

```
./bin/omniglove_bone_deploy_tool \
  --candidate ./calibration-output/candidates/candidate-....ogcal
```

Replace the placeholder file name with the actual generated file. The deploy tool checks the device identity and hand side, writes only to an exactly matching device, and verifies the full readback. By default, long payloads show a 32-byte preview. For diagnostics, use `--full-payload`.

A failed writing does not delete the saved candidate. Keep the full work folder and error output, troubleshoot as described in Appendix B.2 of the **OmniGlove SDK User Guide**, then deploy again. Saving a candidate or completing a write request does not mean the device readback has been verified.

6.5 Diagnostic Input

UDP input is for diagnostics and playback only. Normal calibration with a physical glove uses the automatically detected device:

```
./bin/omniglove_calibration_tool \
  --source udp --listen 127.0.0.1 --port 45550
```