Coordinate Frames and Transformations

1 Data and Coordinate Frame Overview

1. All input is in the transmitter frame (TX frame). Every position and orientation the system receives is a measurement of a fingertip receiver in the transmitter frame.
2. All spatial output is in the wrist frame. Hand keypoints, fingertip targets, and wrist orientation are all expressed in the wrist frame of the current hand.
3. The system outputs no global pose. The output contains no wrist or fingertip position in the robot base, room, or camera frame. If you need one, connect external tracking (§6.2).

Personal calibration links the input frame to the output frame:

```
Glove measurements (TX frame) ──personal calibration──► Wrist frame ──► Joint angles / keypoints / fingertip targets
```

Coordinate frames of each data stream:

Table 1

Data	Reference Frame	Format and Unit
Raw fingertip RX pose (input, one per finger)	TX frame	Position (m) + Euler angles (degrees), intrinsic ZYX, ordered [yaw, pitch, roll]
Raw wrist receiver pose (input, optional)	TX frame	Same as above. The orientation is used for wrist orientation output; the position is recorded only.
POSE native fields (SDK output, input convention)	TX frame	position_mm in mm + yaw_pitch_roll_cdeg in 0.01°; SDK native convention
21 joint angles (output)	Joint variables (not a spatial frame)	rad; For sign conventions, see §2.4 and §3
21 hand keypoint poses (output)	Wrist frame	Position (m) + unit quaternion xyzw
5 fingertip target poses (output)	Wrist frame	Same as above. Derived directly from the sensors; not interchangeable with keypoints (§6.4)

Data	Reference Frame	Format and Unit
Tactile spatial coordinates (mode 1, output)	Wrist frame	Position (m), XYZ; one-to-one with the 746 tactile indices
Wrist orientation (output, may be null)	Wrist frame, relative to the calibration zero	Quaternion xyzw + rotation matrix
Recorded data files	Same as the rows above	Same as above

2 Coordinate Frame Conventions

2.1 Basic Conventions

- Right-handed frames: All frames are right-handed orthogonal frames, compatible with the ROS and robotics ecosystem (metric units, right-hand rule), so they connect directly to existing toolchains. The wrist frame axes follow hand anatomy (§2.2). When you connect to a robot, you still need one explicit mounting transform (§6.2).
- Units: Length in meters, angles in radians. The only exception is input Euler angles, which are in degrees.
- Rotation representation: Output uses unit quaternions with components ordered **xyzw** (some ecosystems use wxyz, so check this when you integrate). **Input uses Euler angles.**

2.2 Root Node: Wrist Frame (Output Reference Frame)

The wrist frame is fixed at the root of the hand model and shared by all output. Its axes follow anatomical directions:

Table 2

Axis	Direction
+X	Radial (thumb side); same for both hands
+Y	Dorsal (left hand) / palmar (right hand); opposite for the two hands
+Z	Proximal (from the finger bases toward the wrist and forearm); same for both hands

The left and right wrist frames are mirror images of each other across Y. +X (radial) and +Z (proximal) mean the same for both hands, while +Y means the opposite: dorsal on the left hand, palmar on the right hand.

2.3 Transmitter Frame (TX Frame, Input Reference Frame)

Table 3

Axis	Direction
+X	Left hand: radial; right hand: ulnar; opposite for the two hands
+Y	Distal (along the back of the hand toward the finger bases); same for both hands
+Z	Dorsal (perpendicular to the back of the hand, pointing outward); same for both hands

- The axes of the TX and the finger rings are nominal mounting directions (design convention: X radial / Y distal / Z dorsal). Personal calibration absorbs actual wearing deviations automatically. No manual correction is needed.
- The wrist receiver is also measured in the TX frame. Its own axes play no part in the output semantics; the system uses only its orientation.

2.4 Joint Angle Sign Conventions

The 21 output joint angles are finger joint variables, not spatial coordinates. The sign rules apply equally to both hands:

Table 4

Joints	POSITIVE（+）	NEGATIVE（−）
Finger MCP / PIP / DIP flexion	Flexion (fingertip bends toward the palm)	Extension
Finger MCP abduction	Fingertip deviates toward the ulnar side (little finger)	Fingertip deviates toward the radial side (thumb)
Thumb CMC rotation	Rotates toward opposition	Rotates away from opposition
Thumb CMC / MCP / IP flexion	Flexion	Extension
Thumb CMC abduction	Abduction	Adduction

3 Left and Right Hand Rules

3.1 Axis Mirroring

Each hand has its own mirrored hand model with its own calibration, joint limits, and configuration. The differences are built into the model and calibration, and no mirroring is performed at runtime. The axis differences follow these rules:

- Wrist frame (output reference): +Y is opposite (dorsal on the left hand, palmar on the right hand); +X and +Z are the same (§2.2).
- Transmitter frame (input reference): +X is opposite (radial on the left hand, ulnar on the right hand); +Y and +Z are the same (§2.3).

The two frames flip different axes, so there is no way to convert left-hand data to right-hand data by negating or swapping axes alone.

3.2 Joint Angle Sign Consistency

The same joint name and the same sign mean the same anatomical direction. Flexion is positive on both hands, so downstream code does not need to negate the right-hand joint angles.

The same joint angle produces the same anatomical motion on both hands. During flexion, the fingertip moves toward the palm on both hands: numerically toward −Y on the left hand and toward +Y on the right hand, which is the same physical direction.

Table 5

Frame	Left Hand	Right Hand
Wrist Frame	X radial / Y dorsal / Z proximal	X radial / Y palmar / Z proximal
Transmitter TX (nominal)	X radial / Y distal / Z dorsal	X ulnar / Y distal / Z dorsal
Finger ring RX (nominal)	X radial / Y distal / Z dorsal	X ulnar / Y distal / Z dorsal

3.3 Data Exchange Restrictions

Table 6

Restriction	Description
Calibration cannot be shared across hands	Each hand's calibration works only with that hand. The system rejects cross-hand use outright and does not fall back silently.
Raw data cannot be solved on the other hand	The axes are doubly mirrored (§3.1), so neither swapping nor negating axes can switch hands correctly. Reprocess the data with the calibration of the matching hand.

4 Frame Hierarchy

4.1 Global Hierarchy

The system's coordinate boundary is the wrist. From the wrist frame outward, it covers the whole hand (palm and five fingers). Everything above the wrist (forearm, body, robot, room, camera) is outside the system:

```
[World / robot base / camera]        ← Outside the system; connected by the user (§6.2)
        ↑
[Wrist tracker]                      ← Outside the system; optional
        ↑ Mounting transform (calibrated by the user)
[Wrist frame] ★                      ← System root · reference frame for all output
        ├── Hand model hierarchy (§4.2)
        └── Glove sensor hierarchy (§4.3)
```

4.2 Hand Model Hierarchy

```
Wrist frame ★ (root · reference frame for all output)
├── Transmitter mounting reference (illustrative only)
└── Palm
    ├── Thumb chain (CMC → MCP → IP → thumb tip)
    ├── Index chain (MCP → PIP → DIP → index tip)
    ├── Middle chain (MCP → PIP → DIP → middle tip)
    ├── Ring chain (MCP → PIP → DIP → ring tip)
    └── Little chain (MCP → PIP → DIP → little tip)
```

4.3 Glove Sensor Hierarchy

The sensors are attached to the wrist frame through personal calibration (fixed, calibrated once) and per-frame measurements (updated continuously):

```
Wrist
└── Transmitter TX frame (input reference)
```

```
    ├── [per-frame measurement] Five fingertip receivers
    └── [per-frame measurement] Wrist receiver (optional)


Transmitter TX frame ──personal calibration──▶ Wrist frame ★ (output reference)
```

4.4 Output Keypoints

The 21 output keypoints are taken from the corresponding joints and fingertips in the hierarchy above, all expressed in the wrist frame:

Table 7

Keypoint	Anatomical Location	Notes
Wrist	Origin of the wrist frame	Always the identity pose (a reference marker, not an external measurement)
Thumb CMC / MCP / IP / TIP	Carpometacarpal / metacarpophalangeal / interphalangeal joint / fingertip	4 points
Finger MCP / PIP / DIP / TIP	Metacarpophalangeal / proximal interphalangeal / distal interphalangeal joint / fingertip	4 points per finger, in the order index, middle, ring, fifth

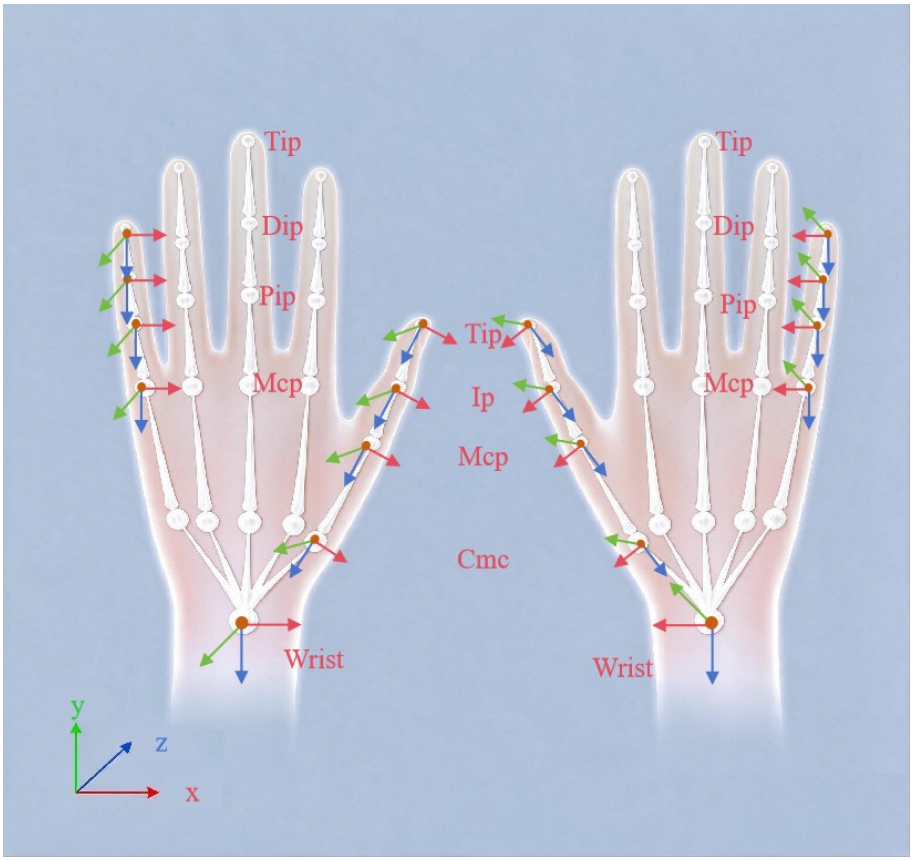


Figure 1

5 Sensor Mounting Parameters

TX mounting parameters (right hand shown):

Table 8

Direction	Reference	Distance	Description
Z-（distal）	Front edge of the housing	28.70 mm	Toward the fingertips
Z+（proximal）	Rear edge of the housing	8.36 mm	Toward the wrist
X+（radial）	Left edge of the housing	25.22 mm	Toward the thumb
X-（ulnar）	Right edge of the housing	25.10 mm	Toward the little finger
Y-（palm normal）	Top face of the housing	2.91 mm	Outward along the back-of-hand normal

RX mounting parameters (right hand shown):

Table 9

Direction	Reference	Distance	Description
Z-（distal）	Front edge of the housing	11.84 mm	Toward the fingertips
Z+（proximal）	Rear edge of the housing	12.31 mm	Toward the wrist
X+（radial）	Left edge of the housing	7.84 mm	Toward the thumb
X-（ulnar）	Right edge of the housing	7.95 mm	Toward the little finger
Y-（palm normal）	Top face of the housing	2.05 mm	Outward along the back-of-hand normal

6 Coordinate Integration Checklist

Before you connect any spatial data, check the coordinate frames, units, and hand side as follows (this continues the checklist in Chapter 7 of the **OmniGlove SDK User Guide**):

1. Confirm whether you are using POSE native measurements, POST model results, or mode 1 tactile points.
2. Check the reference frame, millimeters vs. meters, degrees vs. radians, Euler angle order, and quaternion xyzw order.
3. Select the model and calibration for the actual hand side, and check the positive joint directions against §2.4.
4. When you connect world, camera, or robot coordinates, define the external tracking source and the mounting transform. Check direction and scale with a known motion.

The wrist landmark is a local reference marker. It cannot replace an external wrist position measurement. POSE native fields use the SDK native convention of millimeters and 0.01°; POST keypoints and fingertip targets are in the wrist frame, in meters with quaternions; mode 1 tactile points are in the wrist frame, in meters as XYZ. For the semantics and conversions of all three, see **Data Reference and Quality Guidelines**.