Calibration Guide for CyberGlove

Matt Huenerfauth & Pengfei Lu
The City University of New York (CUNY)

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These directions can be used to guide the process of Manual Calibration of the Immersion 22-sensor CyberGlove using the Device Configuration Utility included with the glove. It's recommended that you read through the entire file once before using the protocol. The "Notes" section at the end may be helpful to read first. You should also become familiar with the names of the various joints of the hand (according to the terminology used by the CyberGlove manual calibration process) before using this guide.

Step 1

Begin by using the device->calibrate-> "automatic calibration" option in the software. This will set the values initially. We will refine these values during the rest of the protocol.

Now select this menu option: device->calibrate-> "advanced." You will see an onscreen hand.

Note: You can change the **offset** value of the **wrist joints** to change the viewing angle of the on-screen animated hand. This can make it easier to see whether the fingers are in the proper configuration. Unfortunately, you do not have the ability to view the on-screen hand from all possible angles. Before you change the **wrist joint offset** values, you should make a note their value immediately after the automatic calibration. This way, you can restore the values back after all of the steps of the calibration process.

Step 2

To calibrate the **inner** and **abduction** joints, follow these steps:

a. For now, it will make the calibration process easier if we "deaden" some of the joints so that they do not move. Set the **gain** values of **outer joints** and **middle joints** of each finger to ZERO – in this order: **Pinky** finger, **Ring** finger, **Middle** finger, and **Index** finger.

   Ask the participant to put their hand palm face-down on a foam-rubber pad. Ask them to put their hand in a 'Flat B' handshape. (We are placing the hand on a foam-rubber pad instead of on the hard table-top so that the participant is not tempted to bend their fingers backwards at the inner joint. The fingers should be occupying the same plane as the palm of the hand, and the "heel" of the palm should touch the pad.) Here is a good time to consider changing the **offset** value of the **wrist joint** to change the viewing-angle to decide whether the hand is flat. Adjust **offset** values of the **inner** joints for the **Pinky**, **Ring**, **Middle**, and **Index** fingers. We want the on-screen hand to also be flat.

   'Flat B' Handshape:  

b. Ask the participant to put their hand in the 'Bent B' handshape. Ask the participant to the back of the hand on the table (palm up) and hold the hand in this position using the other hand if you need some support. The goal of this hand position is to make the **inner** joints of **Pinky**, **Ring**, **Middle**, and **Index** finger bend 90-degrees and to keep the other joints straight. Modify the **gain** values of the **inner** joints of the four fingers to make the handshape on-screen look like the human's hand. Change the **wrist joints offset** value to allow you to view the hand from other points-of-view to make it easier to decide if the hand looks OK. Alternate between 'Flat B' and 'Bent B' handshapes to finish the adjustment of the **gain** of the **inner** joints of the four fingers. The goal is for the on-screen hand to also appear to move 90-degrees. Finally, you can adjust both the **offset** and the **gain** until you are please with the behavior of these **inner** joints.

'Bent B' Handshape: 

'Flat B' Handshape: 

c. Ask the participant to put their hand on a foam-rubber pad in a '5' handshape – keep the hand flat and all fingers as straight as possible. Wedge-shaped foam-rubber pads may be placed between the fingers to keep the fingers spread evenly and as wide as possible. If you measure the degree of the angle of the wedges, then you can modify the **abduction** joint **offset** values to make the onscreen hand match the angles of the wedges. The wedges help the participant to hold the hand position comfortably and accurately. Modify each **abduction** joint's **offset** value to correct the difference between the user's hand and the on-screen animated hand. Set the joints in this order: **Ring**-**Pinky** abduction, **Middle**-**Ring** abduction, **Index**-**Middle** abduction, and finally **Thumb-Index** abduction.

'5' Handshape: 

d. Ask the participant to make a 'Flat B' handshape. The goal of this hand position is to make the abductions of **Pinky**, **Ring**, **Middle**, and **Index** fingers as tightly closed as possible and to keep the other joints straight. (For the abduction joint, being closed is actually the "more bent" position.)

Modify the **gain** values of the **abduction** joints to make the ideal hand look like the 'Flat B' handshape; set the **abduction** joints in this sequence: from **Pinky** to the **Thumb**.

‘Flat B’ Handshape: 

‘5 Handshape: 

Alternate between the ‘Flat B’ and ‘5’ handshapes, and modify the **gain** values of the four **abduction** joints. The goal is for the degree-of-arc of the human’s movement to match the degree-of-arc of the on-screen hand.

When you feel that the gain values look OK, then you can adjust both the **gain** and the **offset** values of the four **abduction** joints.

Note: If the participant is getting tired maintaining these handshapes, then they can use their other hand to help hold the fingers spread in the ‘5’ handshape. Or use the wedges.
Note: Another way to compare the abduction behavior of the participant’s hand to the onscreen hand is to ask the participant to put their hand in front of the animated hand on the screen to compare the angle of the abduction joint movements.

Optional (this takes can take up to 10 minutes additional time):
The human can make the ‘R’ handshape (cross **index** and **middle** fingers) to check that **offset** and **gain** values are still correct for the abduction joints. Ask the participant to switch between ‘R’ and ‘5’ handshapes to further refine the **gain** and **offset** values of the **abduction** joints.

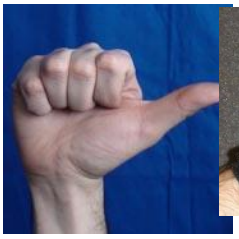
‘R’ Handshape: 

Step 3

To calibrate the **thumb-roll** joint and **inner**/**outer** joints of the **Thumb**, follow these steps:

a. Ask the participant to alternate between the ‘Thumb-Extended A’ and ‘Thumb-Crooked A’ handshapes. The goal is for the participant to achieve a 90-degree angle on the **outer** joint of the **thumb** during the ‘Thumb-Crooked A.’ Thus, the participant should bend and open the **thumb inner** joint as much as possible. First, focus on the gain value of the thumb inner joint. Make sure that the degree-of-arc movement of the on-screen hand matches the participant. When you are happy with

the **gain**, then you can adjust both the **gain** and **offset** values of the **Thumb**'s **outer** joint. When setting the **offset** value for the **thumb outer** joint, it is better to rely on the 'Thumb-Extended A.'

'Thumb-Extended A':  

'Thumb-Crooked A':  

Note: In this step, the four fingers of the onscreen hand will still appear to be straight because earlier we set the **gain** values of the **outer** and **middle** joints to zero. Focus on the **thumb** and ignore the **pinky**, **ring**, **middle** and **index** fingers.

Note: If the participant has small hands and short fingers, the tip of the "thumb" of the glove might be empty. For the calibration, imitate the shape or angle of the glove, not the actual joints of participant's hand. Visually, you want the glove that you see to match the onscreen hand.

b. Ask the participant to alternate between the 'B' and 'Mitten' handshapes. The goal is for the **thumb**'s **inner** joint to bend and unbend as much as possible. For the 'B' handshape, it is not necessary for the thumb to stretch all the way across the palm to the pinky. In fact, it is better if the participant does not use thumb-roll to stretch the thumb that far. It is better for the participant to focus on only moving the **thumb inner** joint of the hand during this pair of handshapes. When in the 'Mitten' handshape, the goal is for the thumb to be extended as far as possible. The **inner** joint of the **thumb** should not be bent at all when in the 'Mitten' handshape. Be careful to observe the angle of the **thumb inner** joint makes. First, set the **gain** of the **thumb inner** joint. The goal is for the degree-of-arc of the on-screen hand to match the participant's movement. After you are happy with the gain, then you can adjust both the **gain** and **offset** values of the **thumb inner** joint. It is better to rely on the 'Mitten' handshape when setting the **offset** value for the **thumb inner** joint.

'B' Handshape:  

'Mitten' handshape:  

c. Ask the participant to alternate between 'Mitten' and 'Thumb Forward B' handshapes. The goal is for the participant to move their thumb 90-degrees during this pair of handshapes. First, you should adjust the **gain** value of the **thumb-roll** joint to match this 90-degree arc movement of the thumb. After you are happy with the gain value, then you can modify both the **gain** and **offset** values of the **thumb-roll** joint. It is better to rely on the 'Mitten' handshape when setting the **offset** value of the **thumb-roll** joint. During this step, you should pay attention to the configuration of the two segments of the thumb and the angle of movement of the thumb-roll; ignore the other fingers of the hand.

'Mitten' Handshape:  

'Thumb Forward B' Handshape:  

Note: If it is more comfortable, the participant can perform these two handshapes in the manner shown below (with the edge of the hand on the table-top and the thumb pointing upwards during the 'Mitten' handshape). In fact, for many of the handshape pairs in this protocol, it may be more comfortable for the participant to orient their hand in this manner (as opposed to putting the back of their palm on the table-top). If you feel that the participant is able to successfully perform the required handshapes, then it is OK for them to use the hand orientation shown below.

You should finish step 3c by asking the participant to alternate between the 'B', 'Mitten' and 'thumb forward B' handshapes to ensure that you are happy with the thumb movement.

Step 4

Now, we will calibrate the **outer** and **middle** joints of the four fingers.

a. Ask the participant to put the back of their hand on the table (palm up) and to alternate between the 'A' and 'Bent B' handshapes. The participant can use their other hand to make it easier to hold the 90° angle of the 'Bent B' handshape. Modify the **gain** values of the **middle** joints for four fingers, in this order: **Pinky** finger, **Ring** finger, **Middle** finger, **Index** finger. The goal is for the degree-of-arc of movement of the participant's middle joint to match the movement of the on-screen hand.

‘A’ Handshape: 

‘Bent B’ Handshape: 

b. You have already set the **inner** joints of the four fingers earlier, but you may want to consider these joints again in this step to make sure they looks OK. Therefore, we will repeat a pair of handshapes that we used before: Ask the participant to put the back of their hand on the table (palm up) and to alternate between the ‘Flat B’ and ‘Bent B’ handshapes. Make *fine adjustments* to the **gain** values of the **inner** joints for the four fingers, following the order from **Pinky** finger, **Ring** finger, **Middle** finger to **Index** finger. The goal is for the degree-of-arc of the on-screen hand’s movement to match the movement of the participant. When you are happy with the gain, you can adjust the **offset** of the **inner** joints of the four fingers. When setting the offset values, it is better to rely on the ‘Flat B’ handshape.

‘Flat B’ Handshape: 

‘Bent B’ Handshape: 

c. Ask the participant to alternate between the ‘S’ and ‘bent B’ handshapes. During the ‘S’ handshape, the participant should curl all of the fingers tightly. You should modify the **gain** values of the **outer** joints for the four fingers, following the order from **Pinky** finger, **Ring** finger, **Middle** finger to **Index** finger. The goal is for the degree-of-arc o movement of the on-screen hand to match the movement of the participant. You may want to look at the participant’s hand from the side to observe the angle of the **inner** joints when the hand is a fist, try to make the hand in the screen looks the same. When you are happy with the gain values, you can adjust both the **gain** and **offset** values of the **inner** joints of the four fingers. It is better to rely on the ‘Bent B’ handshape for the **inner** joints’ **offset** values.

‘S’ Handshape: 

‘Bent B’ Handshape:  

d. There are four joints that work together to control the Thumb’s motion: **thumb-roll**, **thumb-index abduction**, **thumb-inner**, and **thumb-outer** joint. In this step, we want to observe a variety of movements of the thumb to confirm that the settings are correct. Ask the participant to alternate between these six hand handshapes: ‘flat B’, ‘B’, ‘9’, ‘8’, ‘7’, fist (with thumb inside). You should make *fine adjustments* to the **gain** and **offset** values of the **thumb-roll**, **thumb-index abduction**, **thumb-inner**, and **thumb-outer joints**.

‘Flat B’:  

‘B’:  

‘9’:  

‘8’:  

‘7’:  

‘Fist (with thumb-inside)’:  

e. Now, we will make final *fine adjustments* to the **outer** and **middle** joints for **Pinky** finger, **Ring** finger, **Middle** finger and **Index** finger. Ask the participant to alternate between the ’Open E’, ‘S’ (or a fist), ‘Flat B’ and ‘Bent B’ handshapes. Adjust **outer** and **middle** joints’ **gain** and **offset** values if needed.

‘Open E’ Handshape:  

‘S’:  

‘Bent B’:  

Step 5

You should **not** make any changes to the **palm-arch** joint. Use the settings given to this joint by the automatic calibration (in Step 1).

Explanation: Unfortunately, the animation of the hand in the graphical display of the calibration software does not have the ability to bend in order to show a palm-arch. (The animation of the palm would need to have two segments in order to indicate palm arch bend.) So, it is not possible to adjust palm arch manually. Just trust the automatic calibration in Step 1 to set the palm arch.

Because we can’t be 100% confident about the palm arch setting, you should avoid asking participants to perform handshapes during the calibration process in which they would be likely to use palm-arch bending. For example, when performing the ‘6’ handshape (in which the person touches their thumb to their pinky), humans typically bend their palm-arch. Since we can’t see the palm bending on the on-screen animation, we might be tempted to *overcompensate* by adjusting the pinky and thumb settings to make the fingers touch.

Notes:

1. The gloves are very fragile. If you pull on the tan part of the glove, it will break. You are allowed to pull the black part, but you must be gentle. When putting on the gloves, slowly put your hand in the glove, and wiggle your fingers. See the videos on the website for more illustration of the proper technique. This is VERY IMPORTANT to protect the gloves.
2. In our experience: if the degree-of-arc movement traced out by the animated hand appears too large (when compared to the actual movement of the person's hand), then the **gain** value may be too high. If the arc looks OK, the **gain** may be OK, and we should modify the **offset** value. When you are setting the **gain** values, you should pay attention how many degrees-of-arc the human's joint has changed when they move – you want the on-screen animation to have the same degrees-of-arc change. After you think that the degrees-of-arc are correct, then you should modify the **offset** values to get the starting point of the hand to look correct. When modifying the **offset** value, you should pay attention to the handshape in which that joint is in its "unbent" position. Note that for the abduction joints, the "bent" position is when the fingers are not spread, and the most "unbent" position is when the fingers are maximally spread. So, use a '5' handshape when setting offset.
3. To match the angle of the participant's hand exactly, a protractor is possibly needed. You can hold the protractor next to the participant's hand, and you can hold it against the computer screen. This will allow you to compare the on-screen hand and the participant's hand.
4. Different people have different hand flexibility. To hold some difficult handshapes, the participant may need to use their other hand or ask for help from another person. When using another hand to hold a handshape, be careful not to touch the sensor strips on the glove. If you touch a sensor strip, then it will give strange signals to the glove, and the on-screen hand will behave erratically.
5. It is very important to avoid allowing the person wearing the gloves to watch the screen. The participant might bend their hand in strange ways in order to get the effect they want in the on-screen animation. We want them to move their hand naturally and then it is your job (the researcher / calibrator) to get the on-screen animation to look correct.
6. Generally, it is better for the participant to keep their hand on the foam-rubber pad instead of lifting and moving the hand in space. Participants generally hold proper handshapes better when their hand is in a resting position.
7. Once you establish the calibration, store the result for the future use! When you repeat this protocol with a participant whom you have calibrated, then you should SKIP STEP 1 and SKIP STEP 2a. Instead, you should begin the calibration process by loading the calibration settings you saved.
8. **Offset** and **gain** values are used for calibration. **Offset** is the difference between the minimum input of an analog input point and the actual minimum signal received from a field device. **Gain** is the ratio of the full-scale reading to the maximum input. (**Gain** * SensorValue) + **Offset** = AngleOnScreen