# MOTION CAP

# Quick Start Guide

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# Short Introduction

**MotionCap** is a High Precision Head Tracking Software with Six Degrees Of Freedom (6 DOF) which gives its users stable, sensitive, accurate, fast and noiseless head tracking.

**MotionCap** was initially designed to overcome limitations of many existing head tracking solutions both commercial (such as TrackIR, TrackSmooth) and freeware (FaceTrackNoIR, FreeTrack, OpenTrack). It incorporates innovative tracking technology to achieve robust head tracking and sub-pixel accurate head pose estimation with sub-millimeter and sub-degree precision in all axes.

The one of goals of **MotionCap** is a head tracking with maximum possible head rotation angles up to 145 degrees in each axis while keeping extremely accurate and fast response, stability and smoothness for any head pose in that range.

**MotionCap** works great with regular cheap web cameras. It will still work even in imperfect lighting conditions and with any light sources, glares, complicated environment texturing, posters, human faces, tv-screens and reflected sunbeams around you.

**MotionCap** was developed by the true fans of flight simulators for flying themselves because no other existing solution could give them satisfying results alike. It is in everyday use by its creators.

# Chapter 1. Preconditions

## Supported Games and Protocols

**MotionCap** natively supports following Protocols:

- FreeTrack / TrackIR Protocol
- Prepar3D v.4. and v.5 SimConnect API (including new Zoom feature)
- Microsoft Flight Simulator X SimConnect API
- FlightGear Network Protocol
- OpenTrack UDP Protocol

With all that interfaces MotionCap supports more than 700 games, including popular MS Flight Simulator 2020, MS Flight Simulator X, Lockheed Martin Prepar3D, X-Plane, FlightGear, DCS series, Lock On series, IL-2 series, Arma series and many others.

## System Requirements

- Windows 10 64-bit or Windows 7 64-bit Operating System
- Simple regular web-camera with 640 x 480 resolution at 25 or 30 fps or more
- Classic baseball cap
- System Administrator rights for installation process only

## Steps before you begin playing

Before using **MotionCap** for the first time you need to accomplish four important steps:

1. MotionCap Software Installation
2. Making a Tracking Board
3. Making a Calibration Board
4. Calibrating your camera

## Step 1. Installation

Simply run MotionCap Installer executable and follow on-screen instructions.

# Step 2. Making a Tracking Board

**MotionCap** tracking board is a flat cardboard (or any other flat and firm sheet) with glued A4 sheet of paper with five printed tracking markers on it. Resulting cardboard is notched and cut to fit to a baseball cap visor.

Here are steps how to make it:

1. Find PDF or EPS file in < *Users/Public/Documents/MotionCap>* folder after MotionCap installation. It contains two pages. Both pages are required. Print the file on matte coated paper.

   ***Important Note:*** *please make sure you set the scale 1:1 when printing MotionCap PDF or EPS, even if your printer reports it will crop the edges. This will ensure that you get the correct marker spacing and excellent tracking quality. DO NOT USE GLOSSY PAPER.*

2. Get a perfectly flat cardboard (or any other flat and firm sheet) without any creases and folds. The size must be the size of A4 sheet. Pizza or any other thick cardboard will work perfectly ☺ Cut it appropriately.

3. Apply glue to the entire surface of the cardboard, then to the back side of printed A4 sheet and give them to dry for 2 minutes. Then carefully apply paper sheet to the cardboard. First touch centers, then use a piece of cloth to smooth the paper sheet out from center to the opposite sides, and after that from center to opposite corners diagonally.

4. If you are using cardboard, take another sheet of A4 paper and repeat step 3 for its wrong side. This is necessary to prevent cardboard from bending.

5. Let it dry for at least 30 minutes. Watch the drying process and carefully flatten the cardboard if it tends to bend.

6. If the printed markers look gray, peeled or not black enough, we recommend using a thin black pencil (black painting marker) to carefully paint over all markers. Be aware that white splotches and other inconsistencies in tracking markers will drastically decrease tracking quality.

Stay away from the sharp corners of the markers when painting! It's best not to draw near corners at all, because if you reshape any corner, the entire marker will stop working!

7.  Use scissors to notch the cardboard along the five printed, vertical, straight lines below the printed arc starting from the bottom edge straight to the arc. Fold the resulting four strips of paper to the wrong side. Here is your tracking board!

8.  Attach the tracking board to a baseball cap visor using paper strips on the board and two paper clips or clothespins on the sides of the visor. Cut all four strips of paper appropriately to get rid of any excess length.

# Step 3. Making a Calibration Board

**MotionCap** calibration board is a flat cardboard (or any other flat and firm sheet) with a glued A4 sheet of paper with 60 printed round markers. The process is very similar to creating a Tracking Board, except that you don't need to cut anything. Just print it out, glue it to the cardboard as described in previous chapter, and that's it.

# Step 4. Calibrate your camera

For **MotionCap** to work, you need to calibrate your camera. Each camera (even of the same model) has its own unique optical properties, and **MotionCap** needs to know these precisely in order to accurately track your head posture in sub-millimeter and sub-degree quality.

_**Important Note:** The calibration process needs to be done exactly once per any new camera you will be using. Once your cam is calibrated, MotionCap will automatically detect, load and re-use the calibration results for that camera each time you start the application._

_**Important Note:** The application requires Internet Connection to accomplish calibration process._

To calibrate your camera do the following:

1.  Make sure your camera is properly connected and all drivers are installed correctly. The best way to assure that is to open any application that uses your cam and look at the picture from the camera.

2.  Setup your camera right in front of you. The best placement is on top of your monitor or slightly higher. Don't set it under the monitor or on the table, as this will reduce the head pitch (tilt) tracking range.

3.  Start MotionCap. If you haven't done any camera calibrations yet, on the left side you will see Camera Calibration Panel. If it's not there, just open it by pressing (Show Calibration Panel) button.
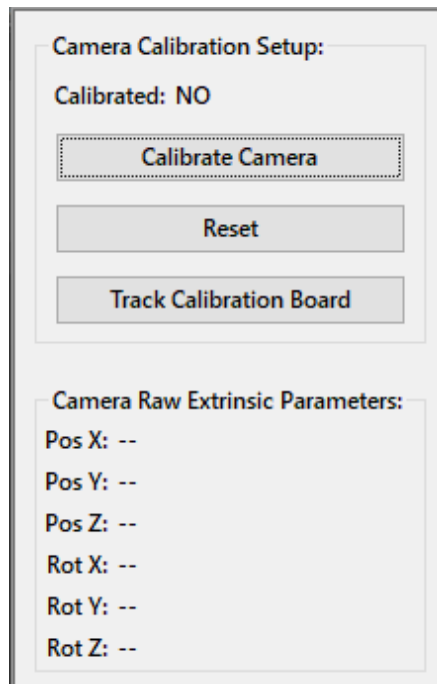


**Fig. 1.**

*Camera Calibration Panel.*

4.  Press "Calibrate Camera" button. Before continue, you will be prompted to enter your **MotionCap** software Serial Number required for calibration:
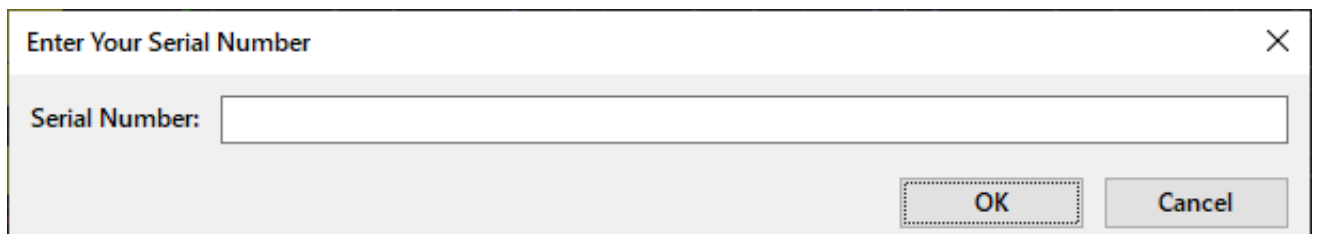


**Fig. 2.**

*Serial Number prompt window.*

Please copy and paste your Serial Number exactly as it was provided. You will not know about its correctness until calibration process will finish. So if you did this point wrong you will see an error message after you complete the calibration sequence and entire process will fail. After completing this form press "OK" button.

5.  **MotionCap** will begin Camera Calibration sequence. You will see opened camera window with "Detecting Calibration Board" message:
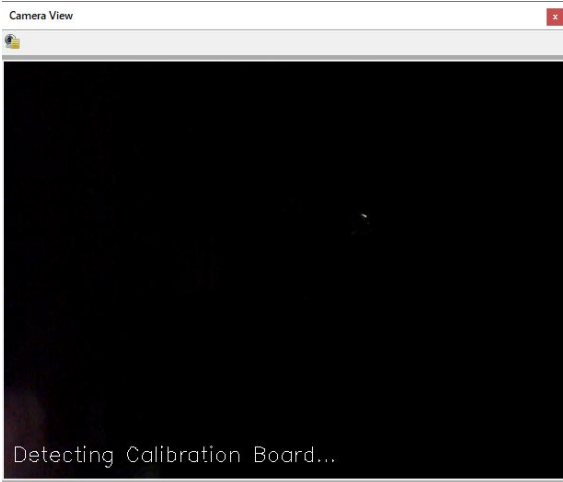


**Fig. 3.**

*Camera Window. Start of calibration sequence.*

6.  Now put your Calibration Board into the camera view, always holding it in landscape  orientation. When it gets properly detected by the **MotionCap** you will see the following picture:
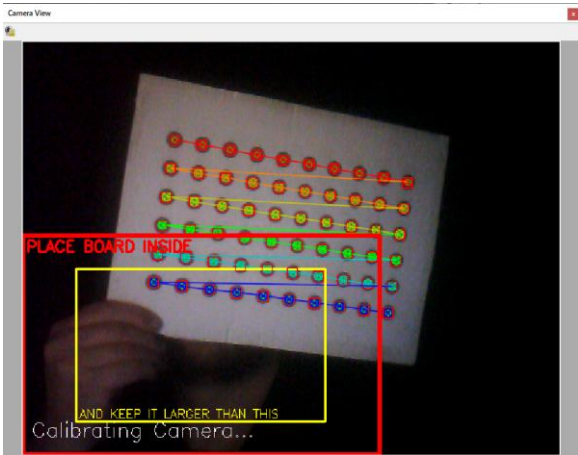


**Fig. 4.**

*Camera Window. First round of the calibration game begins!*

The calibration process is very similar to a mini-game: you have to move the calibration board very slowly and completely place all its points inside the red rectangle, but the area of its points should be larger than the yellow rectangle inside the red one. Once you are successful, the rectangles will jump to the next position and a new calibration round will begin. You will need to repeat these steps for nine rounds in a row until the calibration process is complete. Try to keep the board perpendicular to the screen and move it very slowly to score more points! Good luck!

7. Once you finish ninth round, **MotionCap** will communicate to the **MotionCap Server** on the Internet to check your Serial Number and will calibrate your camera.

There are exactly three levels of calibration quality available: EXCELLENT, GOOD and AVERAGE. Any of these levels is acceptable to do tracking perfectly, although it's obvious that the better levels theoretically capable of giving better results.

***Important Note:** With single Serial Number you can perform <u>up to ten successful calibrations</u>, so in theory you could have up to ten different cameras. Bad calibrations cost you nothing at all.*

***Important Note:** Calibration results will be saved to your local hard drive in the <Documents/MotionCap> folder. You can archive the entire contents of that folder and use it later after re-installing MotionCap, Operating System, or simply on any other computer without having to repeat the calibration process until your camera is replaced with another one.*

***Important Note:** After all ten calibrations have been successfully completed your Serial Number can no longer be used to calibrate camera and must be replaced with a new one.*

# Chapter 2. Playing Games.

## Selecting Game Protocol

As was mentioned in Chapter 1, **MotionCap** supports five Protocols:

- FreeTrack / TrackIR Protocol
- Prepar3D v.4. and v.5 SimConnect API (including Zoom feature)
- Microsoft Flight Simulator X SimConnect API
- FlightGear Protocol
- OpenTrack UDP Protocol

Any of these protocols can be selected using buttons at right side of Menu Bar:



***Fig. 5.***
*Menu Bar with Protocols Selection Buttons outlined.*

**<u>Important Note:</u>** *Only one button at a time can be active. If all buttons are in inactive state then the Default Interface FreeTrack / TrackIR is used.*

Below are Buttons descriptions:

*Prepar3D SimConnect API (including Zoom feature)*

*Microsoft Flight Simulator X SimConnect API*

*FlightGear Network Protocol*

*OpenTrack UDP Protocol*

Below we will explain in greater detail some of unique features of these protocols, including the Default FreeTrack/TrackIR Protocol that is not shown as a button here.
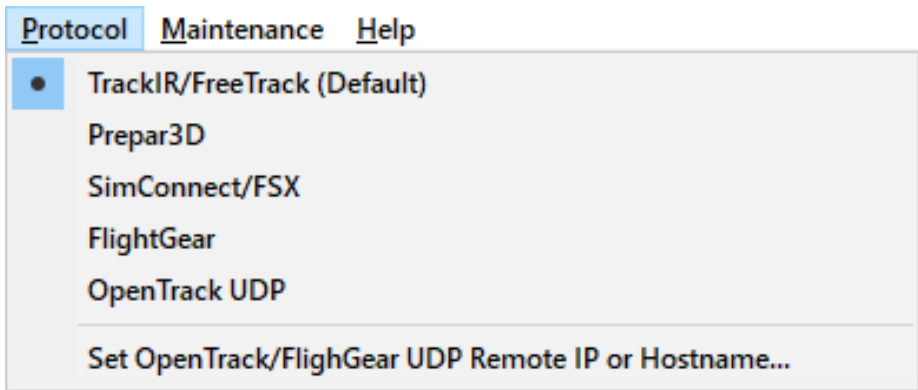
The same list is available via "Protocol" Menu:



**Fig. 6.**

*Contents of "Protocol" Menu.*

FlightGear and OpenTrack UDP Protocols also have options for selecting Hostname (or IP Address) and port number where these servers are running. To set them, select bottom menu line "Set OpenTrack/FlightGear UDP Remote IP or Hostname…" in "Protocol" Menu in order the following dialog to appear:
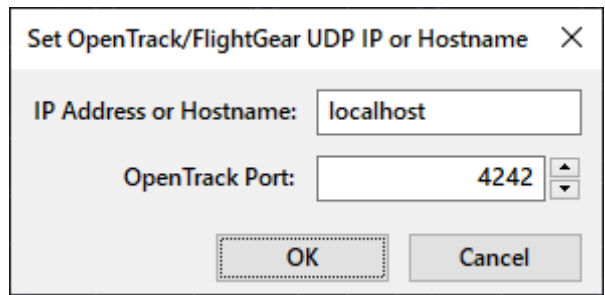


**Fig. 7.**

*"Set Host and Port Number" Dialog.*

If you are playing locally you do not need to change anything here.

# Prepare, start and stop Head Tracking

**_Important Note:_** *Before start Head Tracking please setup your camera right in front of you. The best placement is on top of your monitor or slightly higher. Don't set it under the monitor or on the table top, as this will reduce the head pitch (tilt) tracking range.*

*Make sure you have enough distance between your head and camera in order to give yourself enough space in camera view for head movements. Cameras with wider field of view can be placed closer, while others need more distance.*

*Before start tracking put on your baseball cap with a Tracking Board attached to the visor. Make sure the Tracking Board is in good flat condition and all printed markers are completely black without white or gray splotches.*

To start or stop Head Tracking, simply press ⬛ (Start/Stop Tracking) button in Menu Bar. Alternatively, you can use **Global Hotkey: Ctrl + Alt + Shift + S.**

After you start head tracking **MotionCap** will show Camera Window and begin detection of Tracking Board in camera view:
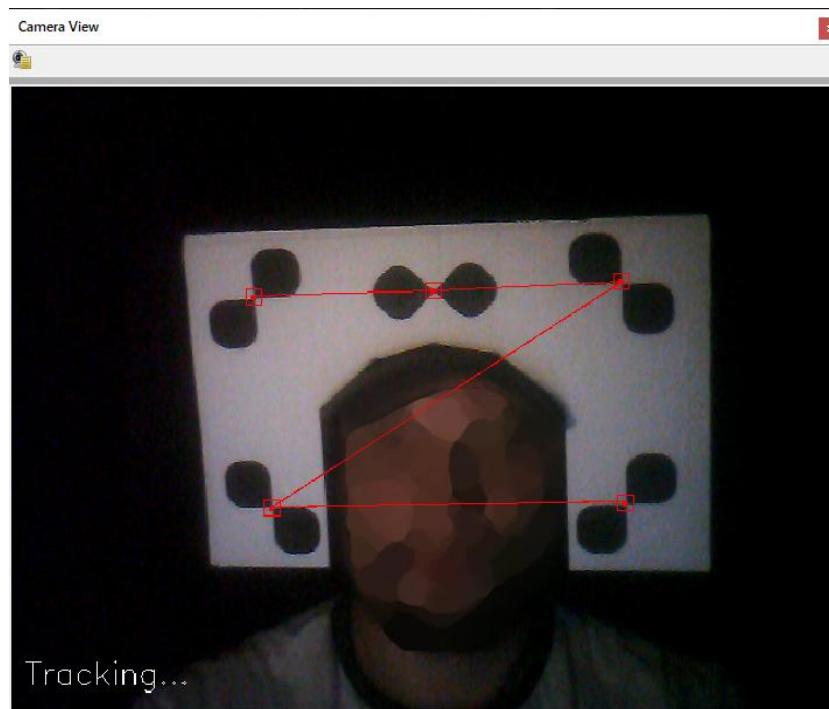


**Fig. 8.**
*Head Tracking is active.*

When all five markers are properly detected, you will see red "Z"-like figure across your face. This means the tracking is in progress and you are ready to play.

If you are using FreeTrack/TrackIR Protocol, MotionCap will automatically detect the game you are playing and will try to find and apply previously saved Game Preset from the *<Documents/MotionCap>* folder.

To stop head tracking for a while press ⬛ (Start/Stop Tracking) button or use **Global Hotkey: Ctrl + Alt + Shift + S** once again.

# Set Zero Pose

Zero pose is a default head pose in a game space when you "look" straight forward and your head shift is zero in all axes. Of course, this often does not correspond with your real head pose relatively to your camera view and this is what ⬤ button (Set Zero Pose) needed for.

When Head tracking is active, get a comfortable pose you want to be your default initial position in a game and press ⬤ button once or use **Global Hotkey: Ctrl + Alt + Shift + Z** to set this pose as your default pose in a game.

While playing a game you can use **Ctrl + Alt + Shift + Z** at any time to set new comfortable Zero Pose.

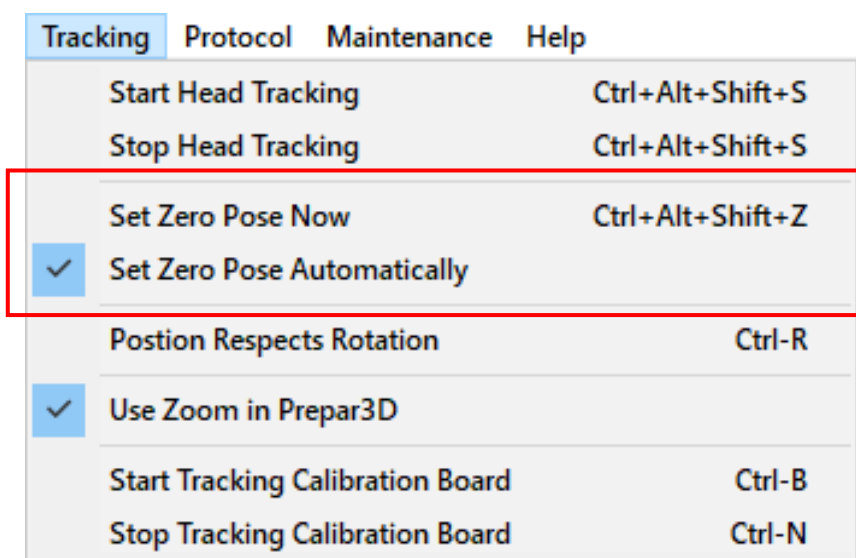Alternatively, you could use "Tracking" Menu to setup Zero Pose:



***Fig. 9.***
*Zero Pose options in Tracking Menu.*

Also take a look at "Set Zero Pose Automatically" option here. This option sets Zero Pose automatically when you press the ⬤ (Start/Stop Tracking) button or select "Start Head Tracking" from "Tracking" menu.

# Chapter 3. Tracking Settings.

## Introduction to MotionCap tracking concepts

Depending on the game you are playing you may want the tracking system to interpret your actual head movements differently. Different games and game events obviously require more or less head movements than others.

For example, piloting military aircrafts, especially in close combat or air show scenarios, require you to have an almost 360-degree view in all directions, keeping an eye on your enemies and allies at the same time, even when they are directly behind you, or using helmet mounted targeting system. The same is about piloting sport aircrafts when performing an air show.

On the other hand, piloting heavy commercial planes requires smaller viewing angles, but more precision and comfortable view stability when dealing with cockpit systems and instruments, such as FMS keyboard and a bunch of small switches and rotary knobs throughout the cockpit.

That is why even a slight movement of your head is worth it. And that is why we have developed a unique motion stabilization system for cases when you require precision combined with comfortable stability of a view.

**MotionCap** gives you absolute freedom of choice in all possible game scenarios. You do not need to switch off tracking system to get into even a small button or precisely rotate a knob by mouse!

## Use 3D Viewport to control your tracking settings

The most space-consuming part of **MotionCap** User Interface is the 3D Viewport. 3D Viewport lets you see the results of your tracking settings interactively.

To navigate in 3D Viewport use mouse buttons by holding them pressed and moving the mouse (dragging):

- Drag with LMB –    Rotate the view
- Drag with MMB or use Mouse Wheel – Move viewpoint forward/backward
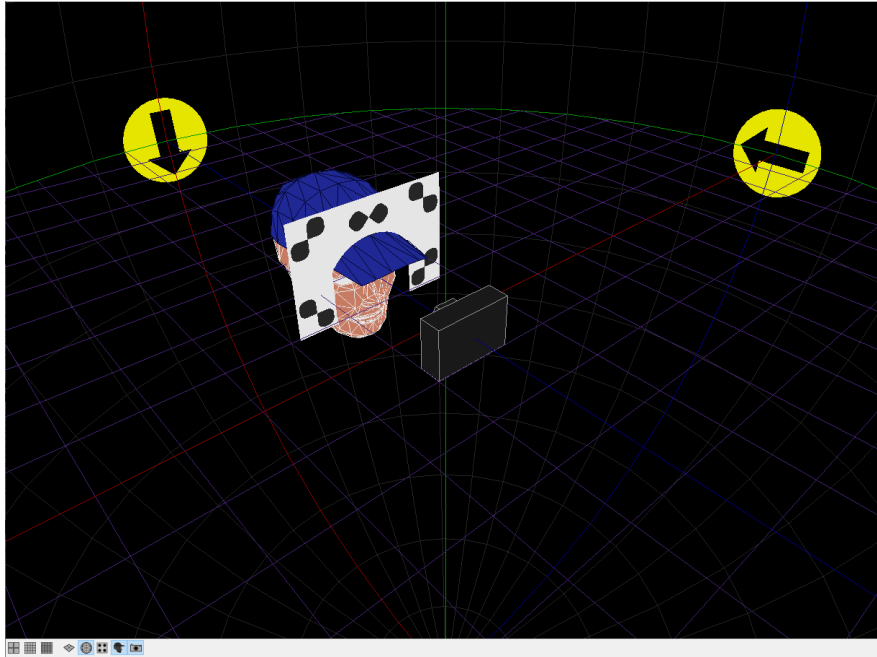- Drag with RMB – Move the viewpoint up/down and left/right

***Fig. 9.***
*3D Viewport.*

Another feature of 3D Viewport is a First Person View Mode which can be activated by pressing the 👤 (First Person View) button on the upper toolbar. When Head tracking is active, this mode gives you exact feeling of a head movements passed by **MotionCap** into the game.

# Tracking Settings panel

Tracking settings are accessible from the right panel of GUI. If you don't see the right panel, press the ⚙ (Show Tracking Settings panel) button on the upper toolbar.

Below we will explain each of tracking settings.

### 1. Movement Smoothness (frames):
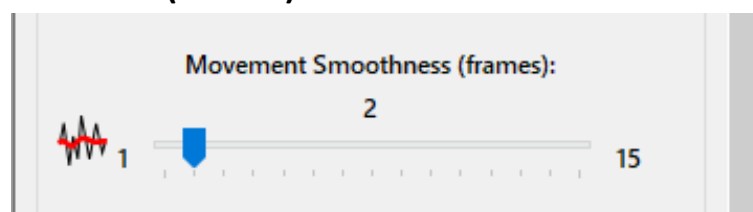


This setting controls how many camera frames the tracking system accumulates to smooth resulting output. This <u>does not</u> mean that having for example 3 frames of smoothness gives you 3 frames lag. You will still get instant reaction to your head

movement, but the result will take into account previous two camera frames to smooth it.

## 2. Stabilization Factor:
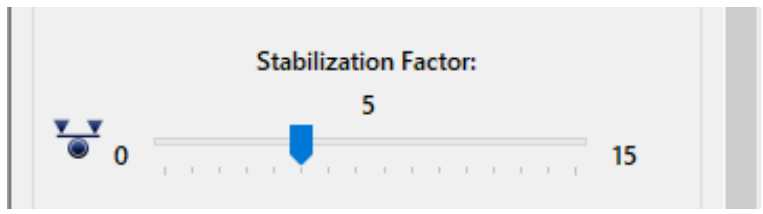


This setting controls the strength of the view stabilization algorithm. The effect of this setting is much like a physical "friction" effect. This means that small head movements with bigger Stabilization Factor will cause less or no net movement.

Bigger Stabilization Factors especially useful when piloting commercial airliners, where you need to keep camera view stable for using mouse within the view and deal with small switches, FMS keyboard, rotary knobs and etc.

Just try it out! You'll love to control all the instruments inside the Virtual 3D cockpit without the need to switch to their on-screen flat equivalents!

## 3. Position and Rotation Axis Sensitivity (%):
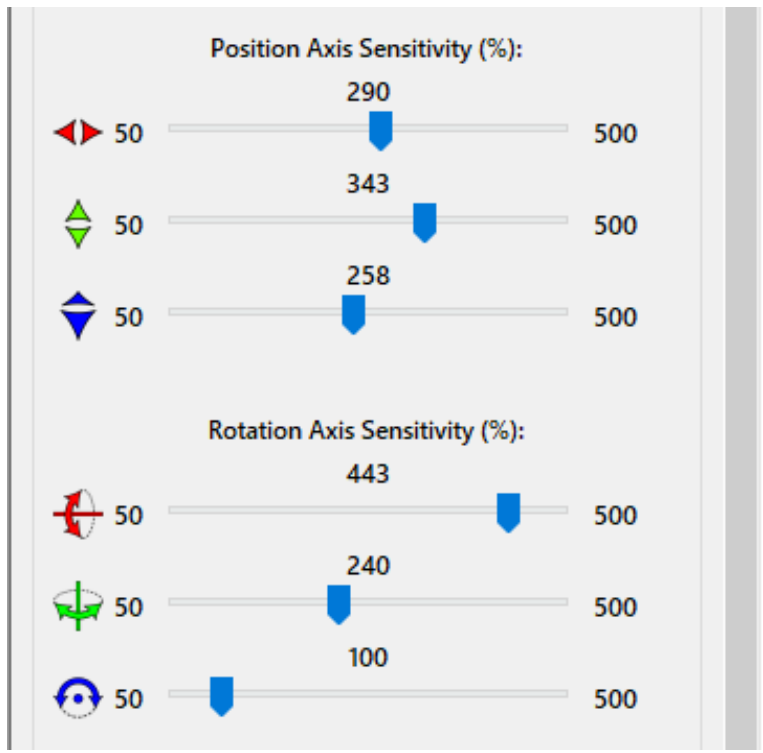
This group of settings controls the influence of real head movements on its virtual equivalent. Sliding these controls to the right will increase your virtual movements, giving you the ability to look backwards or even more with actual head movements just in 45-50 degrees range.

Just keep in mind that setting these to full 500% will require more accurate head movements and probably higher stabilization and smoothing settings above.

To set Sensitivity parameters for all 6 axes right do the following for each axis:

1. Start Head Tracking with ⬤ button.

2. Switch 3D Viewport to First Person View by pressing 🦱 button.

3. Take comfortable pose and look forward to the center of monitor, lean on the back of your chair, then press ⬤ button to set this pose as your Zero Pose.

4. Rotate or move your head to the extreme comfortable position in the right/left or up/down direction and stay still.

5. While keeping your head still, move corresponding slider to get the required extreme rotation/position in the game, controlling it via 3D Viewport.

**4. Sensitivity Response Curves (for Advanced Users):**
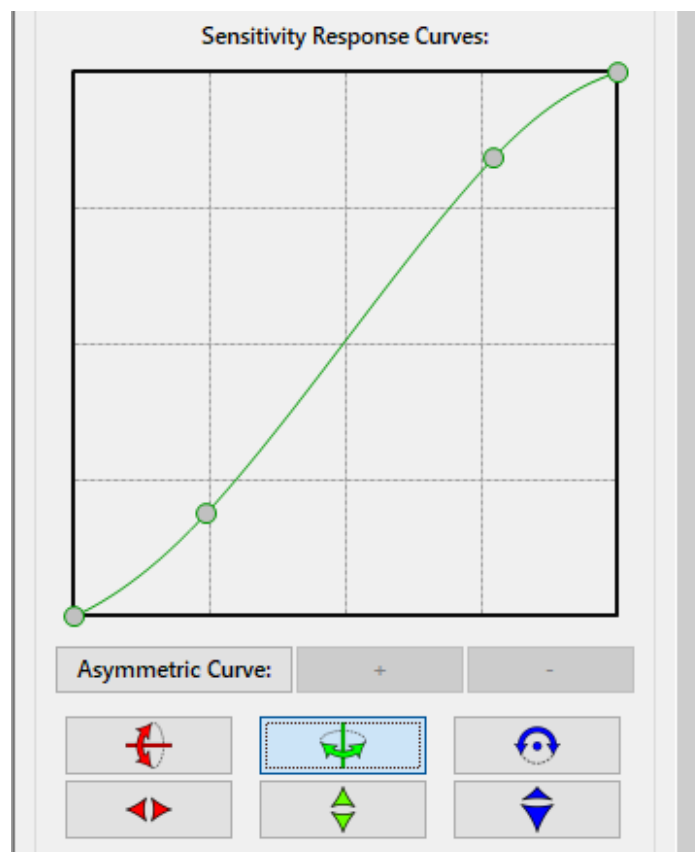
This feature lets you set exact response of the tracking system by mapping input tracking values (horizontal axis) to game output values (vertical axis) using smooth response curves with custom control points for each of 6 axes individually.
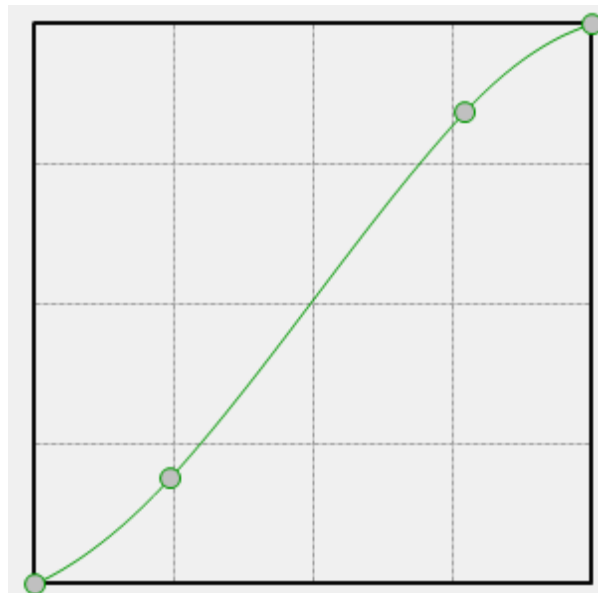
Six buttons with icons below the Graph View let you select the axis you want to adjust:
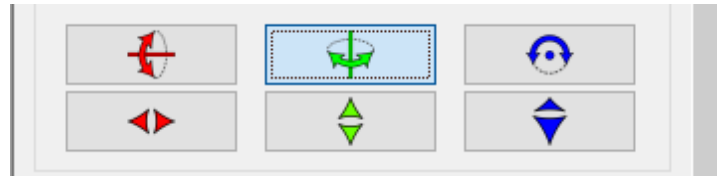


Upper buttons row corresponds to 3 rotation axes (Pitch, Yaw and Roll). Bottom row is for position axes (left/right, up/down and forward/backward). Only one curve (axis) can be selected and manipulated at a time.

The **Graph View** displays the response curve for selected axis:



Here you can:

- Use LMB click on the curve to add new control point.
- Hold pressed LMB on the control point to drag it.
- Use RMB click on the point to remove it.

You can add as many control points as you want. Start and finish points cannot be removed and can be moved only in vertical direction.

When Head tracking is active you can see two coinciding perpendicular gray lines showing you current input/output values.

Using curves is very helpful when you want to set some "dead zones" or zones with lesser sensitivity.

**5. Asymmetric Curve Editing:**

By default, you control only one side of a curve and the other side is symmetrical. In some situations you may want to adjust the curve asymmetrically. This is what "Asymmetric Curve:" button and "+" and "-" buttons below the Graph View are for:
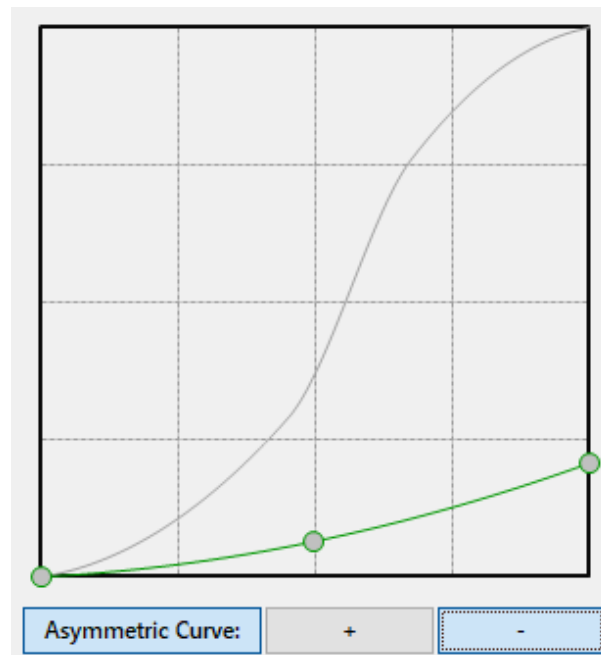


***Fig. 10.***
*Pan (Yaw) axis curve edited asymmetrically.*

Press "Asymmetric Curve:" button to make selected curve asymmetric. Using "+" and "-" buttons you can select Positive or Negative sides of a curve and edit them separately.

This mode is helpful when you want to control your virtual head movement inside the cockpit differently depending on the movement direction.

For example, when piloting Boeing or Cessna, the Commander's seat is on the left side of the cockpit and you want to have more freedom when moving your head to the right side. When your movements are symmetrical, the same movement to the left will cause your head to fly out of the cockpit through the glass. It's the same when you want more freedom when moving your head forward, but don't want your head to "sink" into the seat when you move back. In such cases all you need to do is adjust "left" and "back" portions of the corresponding curves as shown in **Figure 10** above.

### 6. "Position respects rotation" mode:

When dealing with movements of virtual head you can often get confused when trying to move your head in right direction having times increased head rotation angles.

Although in reality your head is rotated just a little, your "in-game head" may be rotated almost 90 degrees more. In such a situation, the movement directions in real life and in virtual space are not the same. This will cause your virtual head to move in wrong direction.

You can enable "Position Respects Rotation" option inside Tracking menu to tell the **MotionCap** tracking system that you want to bind your virtual head movement direction to the real head movements depending on where your virtual head is looking. See **Figure 11** below.

However, this mode also has its own side effects: if you will try to rotate your head with this mode enabled, your virtual head will be orbiting your Zero Pose point.

### 7. Use Zoom in Prepar3D:

Lockheed Martin Prepar3D v.4 and v.5 has more advanced SimConnect API than old MS FSX and gives you the ability to change Field Of View of User Cameras. This feature is utilized by **MotionCap** to switch between forward/backward head movements and Zoom factor of user view. Using Zoom you can view closer any far objects, such as airports, runways, as well as any instruments inside the cockpit. To enable this, simply go to Tracking menu and check "Use Zoom in Prepar3D" menu option.
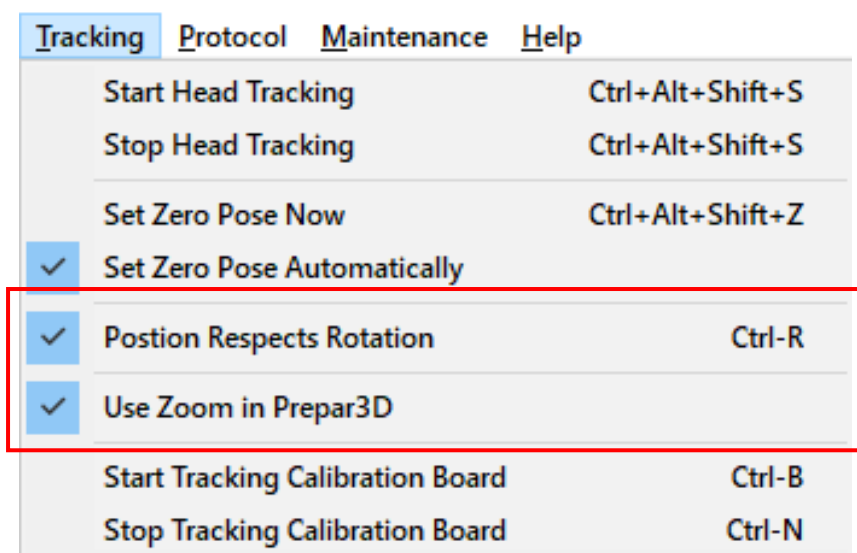


**Fig. 11.**
*"Position Respects Rotation" and "Use Zoom in Prepar3D" switches in "Tracking" menu.*

# FlightGear and OpenTrack UDP connection setup

In order to make FlightGear protocol working, you must perform some additional tasks:

1. Find *<Protocol>* folder inside *< Users/Public/Documents/MotionCap>*.
2. Copy *<Protocol/headtracker.xml>* to *<fgdata/Protocol/headtracker.xml>* inside FlightGear installation directory.
3. Set additional command line arguments to FlightGear application: *--generic=socket,in,25,localhost,5542,udp,headtracke*r

Both FlightGear and OpenTrack UDP Protocols use network connections. Their Network Host Setting is shared between them. FlighGear always use port 5542, while OpenTrack has custom port. You can find "Set OpenTrack/FlightGear UDP Remote IP or Hostname…" Dialog in "Protocol" menu. See **Figure 6** and **Figure 7** on Page 9.

# Chapter 4. Game Presets.

**MotionCap** can save and open Game Presets stored as regular .ini files. Game Preset file contains all of your Tracking settings and some additional technical details for a specific game. Save and load operations are accessible from "File" menu or using buttons at the left side of the upper toolbar.
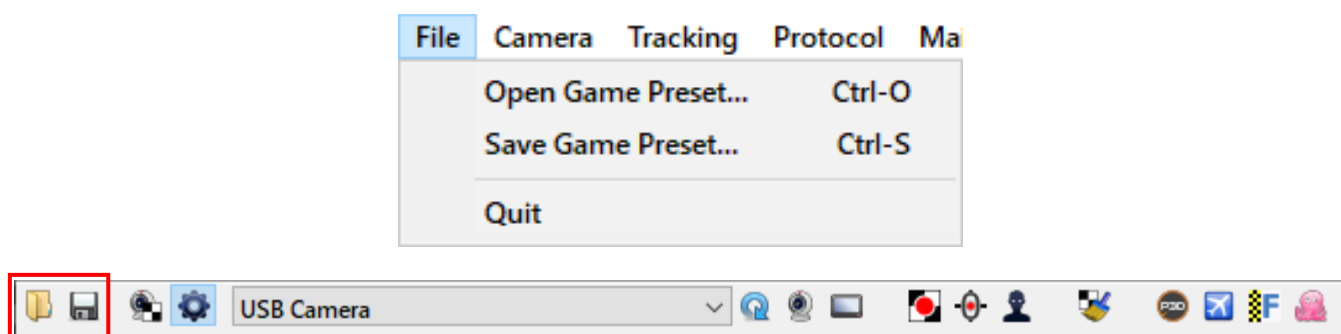


*Fig. 12.*

*"Open" and "Save" operations for Game Presets*

*in "File" menu and upper toolbar*

FreeTrack and TrackIR Protocols can tell to MotionCap the game name. This information is used by MotionCap to automatically search for and load the appropriate game preset (if such are available). All such presets must be located in the *<Documents/MotionCap> folder*.

# Chapter 5. Troubleshooting.

## Camera calibration issues

During camera calibration you can meet with the following difficulties:

1. Calibration process does not start although calibration board is visible in the field of view of the camera. That means you don't see the red and yellow rectangles and calibration board points are not connected by a colored line.

   **Cause 1:** bad lighting. Calibration process requires good lighting.
   **Solution:** Improve your lighting.

   **Cause 2:** poor contrast or calibration board too faded or is not consistently colored. The dots on the calibration board should appear very black and the calibration board itself should be white.
   **Solution:** Print the calibration board using the best quality printer settings. Replace the cartridge in the printer if the calibration board is not consistently colored.

2. Calibration board points are detected along with something else behind it. This can result in poor quality calibration or even inability to perform calibration.

   **Cause:** something behind you looks a lot like black dot on a white background.
   **Solution:** Move calibration board out of the camera's field of view. Use the menu "Maintenance" -> "Run Bad Trackers Cleanup" or activate the  button on the top toolbar. This will start the point detection process and every point detected in camera's field of view will be marked as "Bad Tracker".

Keep it run for 10-20 seconds, then use the "Maintenance" menu -> "Finish Bad Trackers Cleanup" or deactivate 🧹 button on the top toolbar.

Then do not close **MotionCap** open and repeat the calibration process.

3. Everything looks fine, but the calibration process ends with a bad result.

**Cause 1:** you move the calibration board too fast.
**Solution:** Repeat the calibration process, but this time try to move the calibration board as slowly as possible.

**Cause 2:** your PC cannot connect to **MotionCap** Calibration Server.
**Solution:** Check your network and firewall settings. Put **MotionCap** in the list of applications with allowed outgoing connections.

**Cause 3:** your Serial Number is incorrect or has been used to obtain ten successful calibration results and has expired.
**Solution:** Check if your Serial Number is correct. If it has been used for ten successful calibration results, obtain a new Serial Number.

# Head tracking issues

During head tracking you can meet with the following difficulties:

1. Head tracking is not stable.

**Cause 1:** Although the head tracking mechanism is not as sensitive to lighting, there may still be unacceptable lighting conditions, such as:
- complete darkening of marker areas, when white and black areas hardly differ in brightness
- complete overexposure of the marker areas, when white and black areas look the same or almost white

**Solution 1:** The paper used to print the tracking board is very glossy. Print another tracking board, but this time use matte coated paper and make a new tracking board**.**

**Solution 2:** Adjust camera parameters, such as brightness and contrast, until tracking board markers become distinguishable in all critical head poses.

First, display the camera view window if it is not visible by clicking the  button on the top toolbar or using the "Camera" menu -> "Show camera window". In the camera view window, use the  button to display the camera settings. Adjust them accordingly and don't forget to click the "Apply" button at the bottom of the settings window.

**Solution 3:** Adjust lighting conditions**.**

**Cause 2:** The print quality of the tracking board is very poor.

**Solution:** Make sure the markers on your tracking board are completely black. If not, print the tracking board using the best quality printer settings. Replace the cartridge in the printer if the tracking board is uneven in color.

Also make sure that the white areas of the board are completely pure white without any contamination.

If all else fails and the tracking markers still appear grayish rather than black, use a black marker and paint them over carefully as described in Chapter 1, Step 2.

**Cause 3:** You are using calibration data from another camera. This may happen if two or more different cameras you use have the same name.

**Solution:** Disconnect cameras with the same name leaving only one connected. If necessary, repeat the calibration process to obtain correct parameters.

**Cause 4:** Your camera is too close to your head to fully see the tracking board in some head poses.

**Solution 1:** Move the camera further away from your head.

**Solution 2:** Move away from the camera.

**Solution 3:** Adjust the tracking sensitivity to accommodate less head movement and try to stay within the camera's field of view.

**Solution 4:** Replace the camera with one with a wider angle of view.

**Cause 5:** Your camera position is not good for tracking.

**Solution:** Move the camera to the position as recommended in Chapter 2: Prepare, start and stop Head Tracking.

2.  Head Tracking has noticeable latency and/or hopping behavior.

    **Cause 1:** Your camera has a low frame rate. Different cameras have different sensitivity to light. In low light conditions, the camera automatically lengthens the exposure time, which reduces the number of frames it can take per second.
    **Solution 1:** Increase the amount of light in your room.
    **Solution 2:** Decrease camera exposure time manually. First, display the camera view window if it is not visible by clicking the  button on the top toolbar or using the "Camera" menu -> "Show camera window". In the camera view window, use the  button to display the camera settings. Decrease the exposure time, making sure that the visibility of the tracking board still remains at a good level, and do not forget to click the "Apply" button at the bottom of the camera settings window.

    **Cause 2:** The Movement Smoothness parameter is too big. This can be perceived as a tracking lag, although it's not.
    **Solution:** Decrease Movement Smoothness in Tracking Settings panel.

3.  Head Tracking is noisy.

    **Cause:** The current tracking settings make tracking very sensitive to even subtle head movements.
    **Solution 1:** Increase the "Stabilization Factor" setting and/or "Movement Smoothing" slightly. See "Tracking Settings" in Chapter 3.
    **Solution 2**: Decrease Position and/or Rotation Axis Sensitivity. See "Tracking Settings" in Chapter 3.