# Build hardware synchronized 360 VR camera with YI 4K action cameras

**INTRODUCTION**

YI 4K action cameras are perfect building blocks for VR camera. Its video capturing/encoding spec, image quality, battery life and geometry are all great for VR camera. That's why Google chose to work with YI to use YI 4K action camera to build their next version of JUMP VR camera - www.yijump.com.

There are multiple ways to use YI 4K action camera to build VR camera. The difference is mainly about how to control multiple YI 4K action cameras to start and stop recordings. Specifically, we want all cameras to start and stop recording at the same time in synchronized way. This is very important for high stitching quality of 360 VR video.

The simplest approach is to manually control them one by one. It is inconvenient and doesn't guarantee synchronized recording.

A better approach is to use Wi-Fi. All cameras work in Wi-Fi station mode and connect to a smartphone hotspot or a Wi-Fi router. A smartphone App controls all cameras through Wi-Fi channel. The detail can be found in https://github.com/YITechnology/YIOpenAPI.

However, Wi-Fi based solution also has limitations. Firstly, when the number of cameras is large or Wi-Fi interference is heavy, Wi-Fi control is not as reliable as you hope. Secondly, Wi-Fi protocol doesn't guarantee good video capture synchronization among all cameras because Wi-Fi channel is not real time communication channel.

Another solution is to use a Bluetooth remote control to control all cameras. It basically shares the same idea of Wi-Fi solution thus has the same limitation.

There are also solutions which try to synchronize video files offline after recording is finished. It is normally done by detecting the same audio signal or video motion in the video files and aligning them. Since this kind of the solutions do not control the recording start time, its synchronization error is at least 1 frame.

**HARDWARE SYNCHRONIZED RECORDING**

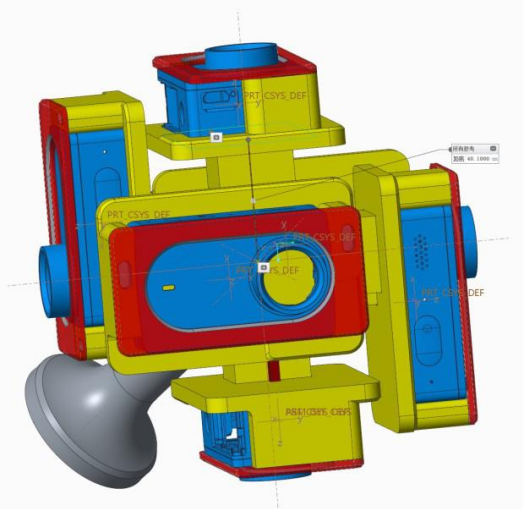
In this article, we will introduce a solution to solve synchronization problem by using hardware synchronization for YI 4K action camera. We use a simple multi-endpoint cable to connect all cameras' micro USB ports and recording start and stop commands are sent over this cable. Since the command is sent on the wire timing is highly real time and accurate. This can bring high precision video capture synchronization among all cameras and significantly improve video stitching quality.

**WHAT YOU NEED**

1. Standard YI 4K action cameras off the shelf of from online


Available at https://www.amazon.com/YI-Action-Camera-Night-Black/dp/B01FU9ZIMU/

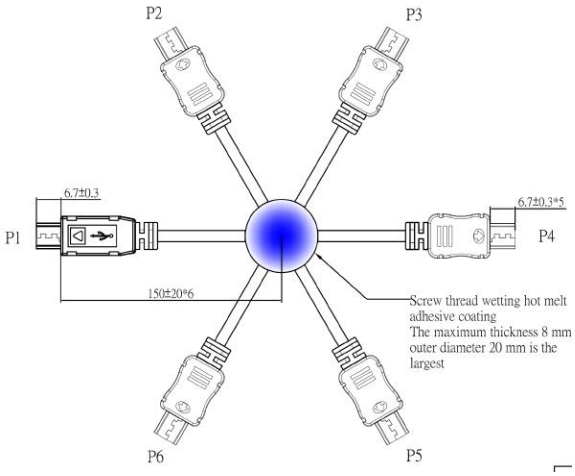
2. 360 VR rig. We have a reference design shared in the same folder. You can 3D print it. Or you can buy YI 4K compatible rig on the market.



The reference design is just one kind of 360 VR camera. You can definitely design your own 360 VR camera with different geometry and different number of cameras.

3. A multi-endpoint cable. We have published its spec in the same folder. Each endpoint is a 7-pin micro USB port. The cable connects all pin 2 together and all pin 7 together. It is a very simple design and you can make one yourself.

   Picture below shows a 6-endpoint cable:




Of course, you can build cable with different number of endpoints if your rig needs different number of cameras.

4. A special firmware. We have released them in the same folder. We will release firmware update periodically so please come back to check the update frequently.

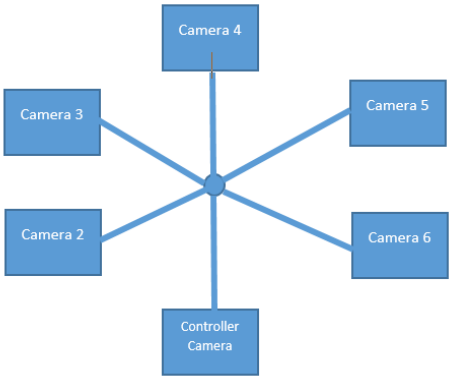
5. Bluetooth remote control (optional).

Available at https://www.amazon.com/YI-Selfie-Bluetooth-Remote-Action/dp/B016I873SO/

**HOW IT WORKS**

In order to have synchronized recording among all cameras, a couple of things need to be done:

1. The multi-endpoint cable connects all cameras' corresponding pins. One camera works as controller camera. User controls the controller camera to start and stop recording. Controller camera send start and stop recording commands to all other cameras.




2. Each camera's firmware is optimized so that after it receives the start/stop recording commands it uses fixed amount of time to prepare for the recording and start the recording exactly at the same time.

3. Each YI 4K camera's crystal is highly accurate. So the clock drift among all cameras is minimum. After recording for 30 minutes the clock drift is less than 10ms. Stop and restart the recording will reset the drift to 0.

All of these guarantees that not only all cameras start the recording at the same time but also keep the synchronization for a period time which is long enough for a typical shot in video shooting.

**HOW TO SETUP**

There are a couple of steps to put everything together to setup the 360 VR camera.

1. Download the firmware files from the same folder. There are two files. One is *firmware_first.bin* and the other is *firmware_others.bin*.
    a. Select one camera as controller camera. Rename *firmware_first.bin* to *firmware.bin* and copy it to the root folder of the camera's microSD card. Insert the SD card to the camera, turn on the camera, and follow instruction on the screen to update the camera's firmware.
    b. All other cameras are non-controller camera. Rename *firmware_others.bin* to *firmware.bin* and copy it to the root folders of the microSD cards of all non-controller cameras. Insert the microSD cards to the cameras, turn on the cameras, and follow the instruction on the screens to update the cameras' firmware.
    c. Using the touch screen to set the cameras to work on desired mode. Three modes are supported: 12MP photo, 2.5K video and 2.5K time lapse video. Please make sure all cameras are working in the same mode.

2. Pair the Bluetooth control with controller camera (optional)
    a. Go to system setting of controller camera
    b. Select Bluetooth Pairing
    c. Keep pressing a button on the Bluetooth control until light on Bluetooth control turns blue.

3. Install all the cameras on the VR rig.

4. Use the multi-endpoints USB cable to connect USB ports of all cameras. Each port of the cable is identical so it doesn't matter which endpoint of cable connects with which camera's USB port.

Picture below is a real example.

**HOW TO USE**

1. Power on
    a. Press and hold each camera's power/shutter button to turn on the camera.

2. Record video or time lapse video
    a. Change all cameras' mode to video or time lapse video.
    b. Press Bluetooth control's shutter button or control camera's power/shutter button to get all cameras ready for recording.
    c. Press Bluetooth control's shutter button or control camera's power/shutter button again to start recording
    d. Recording your video.
    e. Press Bluetooth control's shutter button or control camera's power/shutter button to stop recording. We recommend you limit each of your shot to be less than 30 minutes so clock drift is below 10ms. You can record multiple shots as long as your cameras' microSD cards still have space and batteries still have power.

3. Take photo
    a. Change all cameras' mode to photo.
    b. Press Bluetooth control's shutter button to take a photo.

4. Power off
    a. Press and hold power/shutter button of the controller camera to turn off all cameras.

5. Stitch

a. There is no special thing here. Just use whatever stitching software you like to process the recorded video files to generate 360 VR video.

**FUTURE PLAN**

In the next version we will provide two new features:

1. External battery support so you can use large external battery to power all cameras in the rig. Using large external battery not only gives longer battery life but also make user experience much simpler by avoiding the task of replacing internal batteries.

2. Auto sync settings of all cameras in the rig. Select a group of settings in controller camera, the new settings will be automatically synced to all other cameras. This will also significantly simplify the user experience of operating the VR camera and reduce the risk of out of sync settings.

**HELP AND SUPPORT**

Please contact openapi@yitechnology.com to get help or support. We would also be very happy to hear your feedback and suggestion.