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A Head Mounted Capture System

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Abstract

The present disclosure provides a physical interface (i.e. a serial link cable) for coupling a head mounted capture (HMC) system to a host receiver. The HMC system includes a multi camera aggregator, a plurality of pulse density modulation (PDM) microphones and a hardware (HW) serializer. The multi camera aggregator further includes a plurality of camera sensors. Each of the plurality of camera sensors provides capture data (i.e. images or videos captured by each of the plurality of camera sensors) as an input to the HW serializer via a camera serial interface (CSI). The plurality of PDM microphones provides audio time-division multiplexed (TDM) data as an input to the HW serializer. The HW serializer converts the capture data and the audio TDM data into an 8B/10B coding serial bit stream and transmits it to an HW de-serializer at the host receiver via the serial link cable. The HW de-serializer converts the 8B/10B coding bit serial stream into the capture data and the audio TDM data. The capture data and the audio TDM data is further fed into an adapter printed circuit board (PCB) at the host receiver that provides seamless transitions among various system-on-chips (SoCs), application-specific integrated circuits (ASICs), etc.

Problem statement

Figure 1 illustrates a hardware architecture of a head mounted capture (HMC) system installed within a head mounted display (HMD) device in prior art. The HMC system includes a multi camera aggregator that further includes a plurality of camera sensors and a plurality of pulse-density modulation (PDM) microphones. Each of the plurality of camera sensors is interfaced to an embedded board, for example, a field programmable gate array (FPGA) board, a high-end system-on-chip (SoC) etc. using a camera serial interface (CSI). In one example, the CSI is a mobile industry processor interface (MIPI) CSI. The CSI is a physical link, which has a maximum length of around 20 cm. This puts a limitation on a location of the embedded board. So, the embedded board needs to be co-located or in a close proximity of the plurality of camera sensors to receive capture data (i.e. images or videos captured by each of the plurality of camera sensors) from the plurality of camera sensors. The embedded board is also configured to receive the audio TDM data from the plurality of PDM microphones. The embedded board is further connected to a universal serial bus (USB) microcontroller (MCU), which is interfaced to a host receiver via a host capture interface.

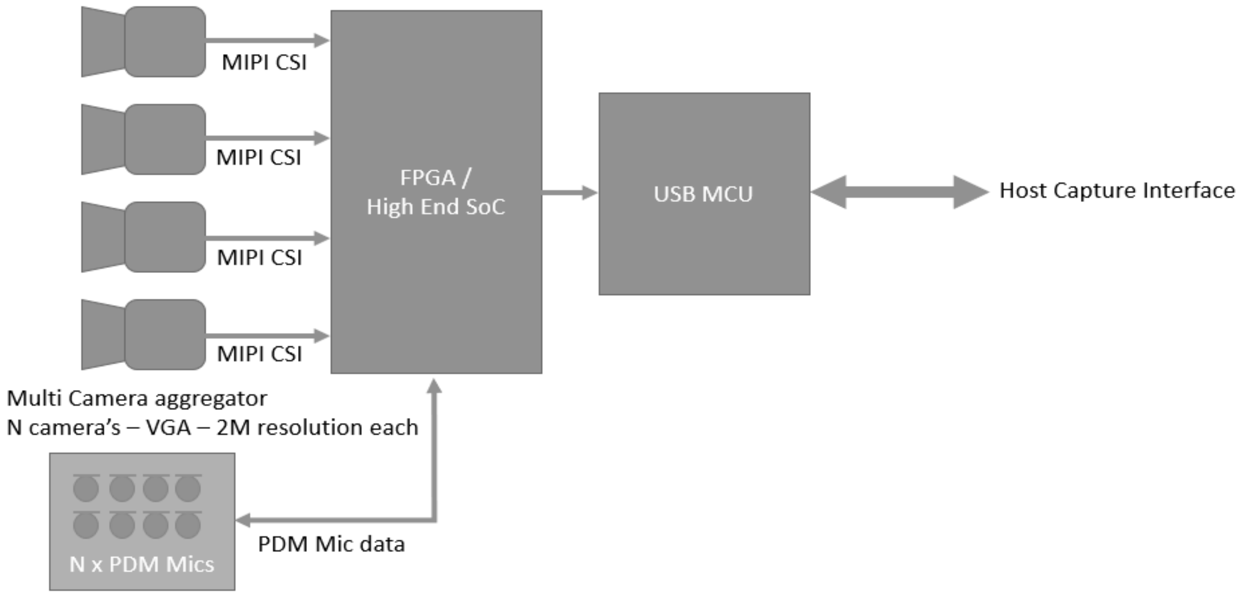

Figure 1: An existing design of the hardware architecture of the HMC system

Figure 2 illustrates an expanded view of the HMC system. Eight camera sensors are shown connected to the embedded board in the center.

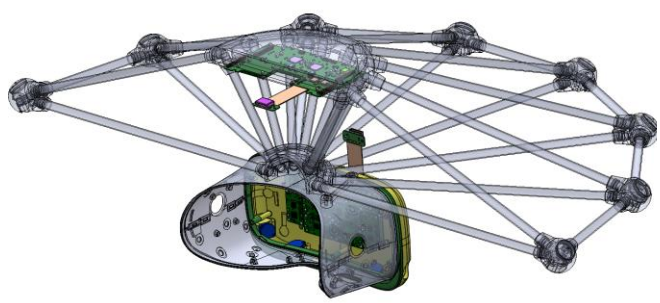

Figure 2: Expanded view of the HMC system

Figure 3(a) and Figure 3(b) illustrate that the plurality of camera sensors is connected to an aggregator printed circuit board (PCB) hub having a plurality of aggregator PCBs (which are interfaced to a transceiver and hub controllers) via a plurality of breakout boards. Therefore, a large space is required to accommodate all these components in the HMC system. Further, a lot of power (approximately 12W) is consumed within the HMC system. Also, a number of components have to be added to facilitate thermal dissipation and heatsinking, but this adds weight to the HMD device and thus causes inconvenience to a user wearing the HMC system. In addition to this, a lot of cables are required to connect all these components together, which further adds weight to the HMD device.

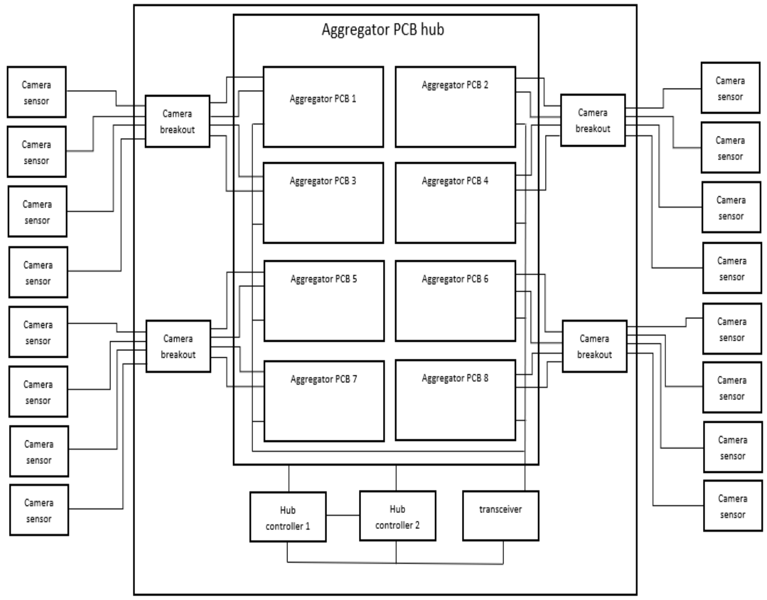

Figure 3(a) A cluster of the plurality of aggregator PCBs, the transceiver and the hub controllers in the HMC system (left) and Figure 3(b) A circuit diagram of the plurality of camera sensors interfaced to the aggregator PCB hub, the transceiver and the hub controllers (right)

Further, in order to connect the HMD device to a PC, or a video game console etc., a bunch of USB and display cables are required. This causes incovenience and difficiulty to the user in handling the tethered HMD device.

The present disclosure provides a novel solution to address the aforementioned problems.

System and working

The present disclosure provides a physical interface (i.e. a link cable, for example, an AC coupled 6/12 Gbps serial link) for coupling a head mounted capture (HMC) system to a host receiver.

Figure 4 illustrates a hardware architecture of the head mounted capture (HMC) system. The HMC system includes a multi camera aggregator, a plurality of pulse-density modulation (PDM) microphones and a hardware (HW) serializer. The multi camera aggregator further includes a plurality of camera sensors. Each of the plurality of camera sensors is interfaced to the HW serializer using a camera serial interface (CSI). In one example, the CSI is a mobile industry processor interface (MIPI) CSI. Each of the plurality of camera sensors provides capture data (i.e. images or videos captured by each of the plurality of camera sensors) as an input to the HW serializer via the CSI. The HW serializer is also configured to receive audio time-division multiplexed (TDM) data from the plurality of PDM microphones. The HW serializer converts the capture data along with the audio TDM data into an 8B/10B coding serial bit stream, which is highly reliable. The HW serializer transmits the 8B/10B coding serial bit stream to an HW de-serializer at the host receiver via the link cable. The link cable has a length of around 10 m, and hence the host receiver may be placed at a maximum distance of around 10 m away from the plurality of camera sensors. This way, signal processing (i.e. processing of the capture data and the audio TDM data) is deferred to the host receiver, and offers following advantages:

- Extremely low power consumption (approximately 3.5W) within the HMC system
- Reduced printed circuit board (PCB) area within the HMC system
- Extremely compact size of the HMC system (this can be utilized to provide a USB-type C connection to the HMC system)

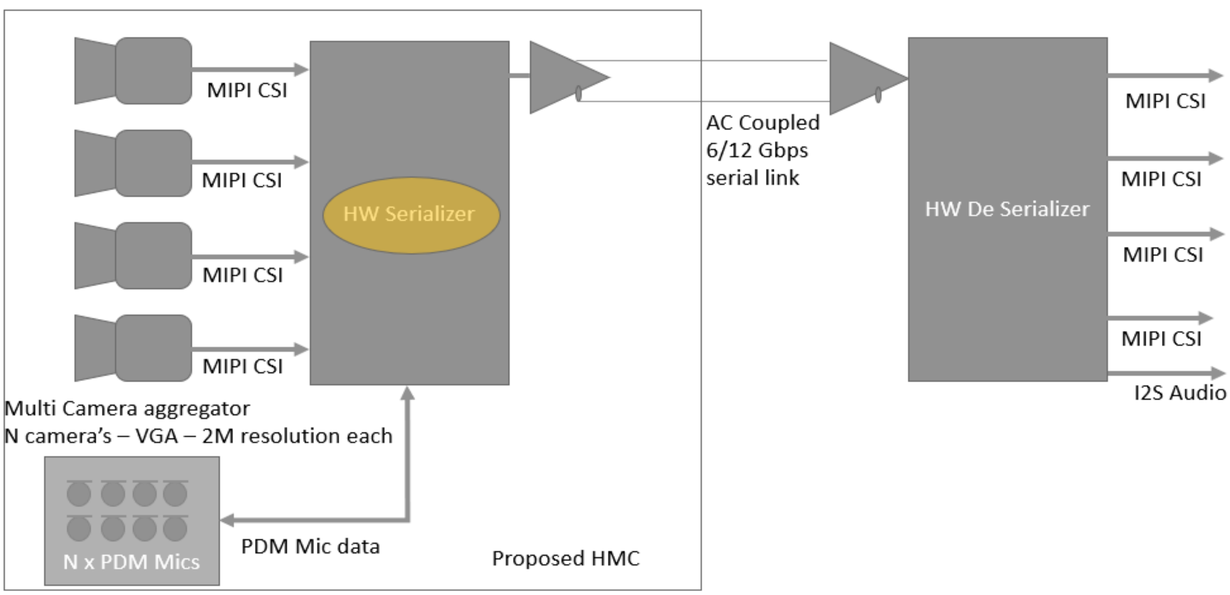

Figure 4: The hardware architecture of the HMC system, which is coupled to the host receiver

Figure 5 illustrates a hardware architecture of the host receiver. The HW de-serializer converts the 8B/10B coding serial bit stream into the capture data and the audio TDM data. The capture data is further fed into an adapter printed circuit board (PCB) via a plurality of CSI interfaces, and the audio TDM data is fed into the adapter PCB via an integrated inter-IC sound (I2S) audio interface. The adapter PCB is modular and provides seamless transitions among various system-on-chips (SoCs), application-specific integrated circuits (ASICs) etc.

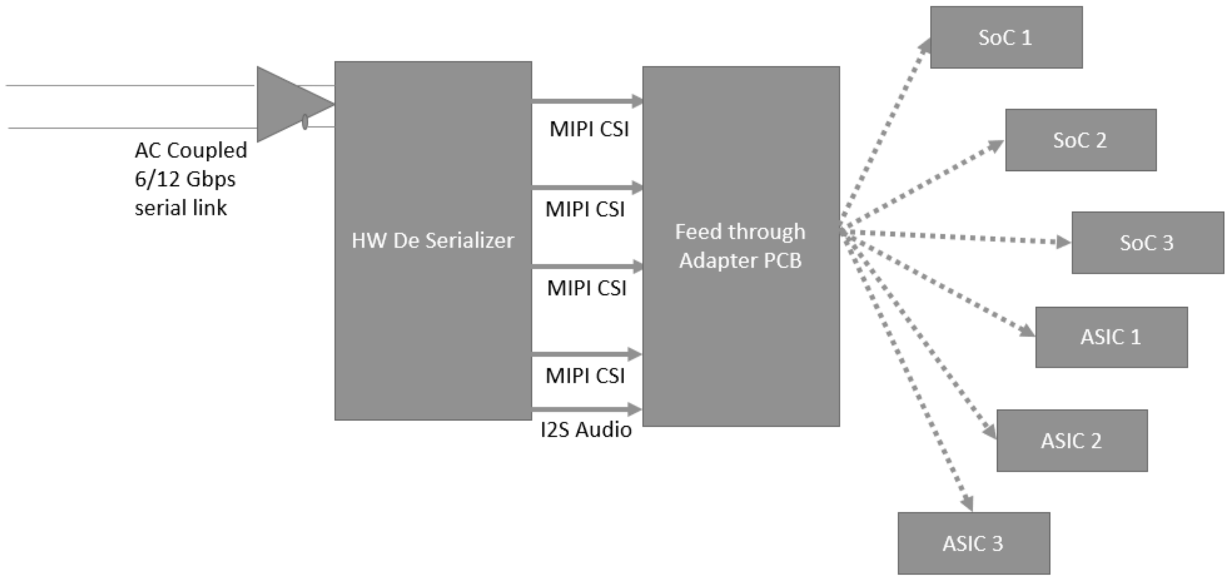

Figure 5: The hardware architecture of the host receiver

Additional embodiments

In another embodiment, the hardware architectures as illustrated in the Figure 4 and the Figure 5 are further accompanied with a design improvement that enables a head mounted display (HMD) device to be used as a mobile phone accessory. Figure 6 illustrates a hardware architecture of the HMD device that enables the HMD device to be used as the mobile phone accessory. The HMD device includes the HMC device and a display module. The HMC device further includes the multi camera aggregator, the plurality of pulse-density modulation (PDM) microphones and the HW serializer. The multi camera aggregator further includes the plurality of camera sensors. Each of the plurality of camera sensors is interfaced to the HW serializer using the camera serial interface (CSI). Each of the plurality of camera sensors provides the capture data as the input to the HW serializer via the CSI. The HW serializer is also configured to receive the audio TDM data from the plurality of PDM microphones.

The plurality of PDM microphones provides the audio TDM data as the input to the HW serializer. The HW serializer converts the capture data and the audio TDM data into the 8B/10B coding serial bit stream. The HW serializer transmits the 8B/10B coding serial bit stream to the HW de-serializer at the host receiver via the link cable. The HW de-serializer converts the 8B/10B coding serial bit stream into the capture data and the audio TDM data. The capture data and the audio TDM data is further fed into a smartphone having type-C capability via a single type-C cable for both power and signal.

The HW de-serializer is also configured to receive display data from the smartphone via the single type-C cable. The HW de-serializer transmits the display data received from the smartphone to a serial-to-DSI converter via a second link cable (for example, an AC coupled 16 Gbps serial link). The serial-to-DSI converter is embedded within the display module included in the HMD device. In one example, the serial-to-DSI converter is a serial to MIPI DSI converter. The serial-to-DSI converter finally projects the display data on to a display screen associated with the display module.

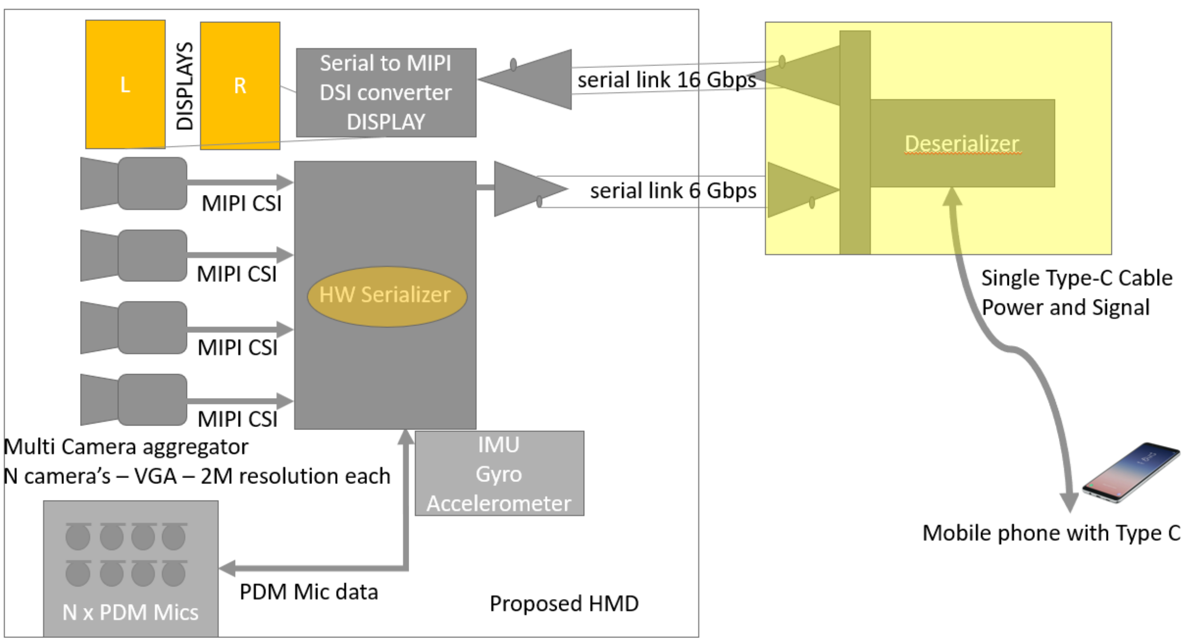

Figure 6: Hardware architecture of the HMD device as the mobile phone accessory

In yet another embodiment, the HW serializer is also configured to receive sensor data from other sensors, such as, an inertial measurement unit (IMU), a gyroscope, an accelerometer etc.

In a yet another embodiment, the HMD device may be connected to a number of hardware systems via the single type-C cable. This serves as a platform for research since the HMD device can work with many hardware systems.

Conclusion

There has been a lot of technical innovations and research happening in the improvement in the design of virtual reality headsets around the world. These technical innovations and research are aimed at enhancing the user experience in a virtual environment. Key design parameters for consideration have been power consumption, weight, PCB area, heat dissipation, and the like. Researchers strive forward for reducing power consumption, weight, PCB area, heat dissipation, etc. The present disclosure also endeavors to achieve these targets by introducing a hardware architecture of the HMD device, which is more reliable and weight efficient. This hardware architecture of the HMD device also eliminates the need for a bunch of USB or display cables for connecting the HMD device to high-end smartphones, PCs, video gaming consoles, and the like.