Live Capture with Parallel Processing
Richard Lince, Technical Business Development, Datapath Ltd.

Richard Lince, 16/01/2014, v1.1

Lower Latency
The increasing demand for low latency video capture to display continues to push the boundaries of technology applications. A fraction of a frame time is now considered as important as full frame latency savings. Solutions driving the decrease in end-to-end pipeline latency cover a variety of markets, including security, medicine, robotics, video conferencing and live media events. Throughout this document we look at further development opportunities for lowering video latency in digital capture and production processing systems.

Examples of production processing include:

- Telepresence encoding
- Live event projector blend
- Live event image warp
- Video display overlay

Consider a local capture image process pipeline below for a 1080p 60Hz video frame:

camera - Latency from scene capture to start of video raster
capture - Latency taken to ingest the video frame
transfer - PCIe transfer latency for 1080p true colour
process - Simple output buffer pixel operation latency
display - Back buffer to front buffer display flip and output raster latency. This maybe variable when the input source is not synchronized (frame locked) to the display output.
The above example shows an 'action to eyeball' latency of 74.9 ms.

**Lowering Latency**

Datapath Vision frame grabber hardware can contribute to lowering end-to-end latency for systems utilizing the PCI express bus topology. The saving can be generated through a combination of existing Datapath LiveStream and MultiStream technologies. Full details of the existing features can be found at the following URL: [http://www.datapath.co.uk/products/video-capture-cards/capture-card-features](http://www.datapath.co.uk/products/video-capture-cards/capture-card-features)

Existing Datapath LiveStream technology transfers lines of data as the input arrives into the hardware capture frame store rather than completed fields or frames. As lines of video enter the frame store, lines are DMA'd to the application defined destination. This process decreases the image processing pipeline above by the DMA transfer time since all the DMA overhead is now in parallel with the frame capture.

To further lower the latency an application might benefit from parallel processing data from the upper parts of an image whilst the video frame is still being captured.

To do this, an application can divide the LiveStream process into 8 smaller horizontal stripes when working on a single captured frame for example. A single horizontal stripe represents an existing Datapath MultiStream client. The frame store could be split into 8 client stripes, each with an independent source area of interest. Once a client stripe has completed its data transfer to the user defined destination, the Vision driver notifies the calling application using a call back thread. For a 1080p 60Hz input video signal, an application will be notified roughly every 2ms (16.6ms / 8 clients). Each of the client stripes can be identified in the applications call back function using a common timestamp representing the start of the video frame capture.

The application may wish to allocate a contiguous frame buffer in virtual address space anywhere on the system and then divide the block into 8 destination apertures. Using this combination of LiveStream DMA and MultiStream client capabilities reduces the latency by the DMA transfer and processing time respectively.
Looking again at the simple use case, 1080p 60Hz with 10ms processing time:

Last line DMA transfer time is 1.8 ms
Processing of the final stripe is 1.3 ms (10/8)
Total 58ms, a reduction of 16.9ms

This example is typical and can vary depending on the video input frame rate and data processing time.

The Vision capture hardware capable of providing this functionality includes support for the following input signal types: SD-SDI, HD-SDI, 3G-SDI, HDMI, DVI, 3-4&5 Wire RGB, Component, S-Video, SECAM and composite with Display Port capture support expect soon.

Additional MultiStream benefits are included in the proposal. Vision capture hardware adds no additional latency overhead for independent DMA client areas of interest (cropping), scale factor, frame rate, de-interlacing and colour space conversion for all and any of the 8 client stripes.

**Parallel processing usage model**

**Encoding stripes to slices**

The h.264 compression tool set allows sub-frame slice encoding of macro block data over full video frames. Using the proposed soft parallel processing technique detailed above, a slice encode can be performed as the video enters the frame store. A complete slice header is created from one of the 8 client stripes and conveys information common to all macro blocks in the slice. This also includes the frame number that the slice corresponds to, reference picture settings and quantization parameter. Slices can then be transferred across the network using single frame VBV support for low latency decoding.
Blending and warping

Using a pixel mesh, stripes of the input raster can be mapped to a second destination buffer. This operation reduces the input to output latency to a 8th of the original post processing time, assuming that the original processing duration is less than a single frame time.

Summary

Sub frame CODECs such as Motion JPEG, H264 and HEVC provide a soft solution for PCIe based capture and encode systems. The advantages of such systems include further latency reduction, reduced costs, soft functional substitution and real-time control. Video conferencing applications can be provided with an opportunity to swap soft CODECS to cater for different video call formats at run time.

Real time processing systems for pixel mapping or image overlay benefit from the same interface proposal outlined in this document. However, the responsibility of an application solution requires third party development in combination with the proposed methods outlined above.

Please contact Datapath if you have any queries, usage models or suggestions regarding this proposal.

technical@datapath.co.uk
Technical Business Development
Datapath Ltd
Bemrose House
Bemrose Park
Wayzgoose Drive
Derby
DE21 6XQ