HDR-ARtiSt: A 1280x1024-pixel Adaptive Real-time Smart camera for High Dynamic Range video

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Abstract 1 (300 words)

Standard cameras capture only a fraction of the information that is visible to the human visual system. This is specifically true for natural scenes including areas of low and high illumination due to transitions between sunlit and shaded areas. When capturing such a scene, many cameras are unable to store the full Dynamic Range (DR) resulting in low quality video where details are concealed in shadows or washed out by sunlight.The imaging technique that can overcome this problem is called HDR (High Dynamic Range) imaging.

This paper describes a complete smart camera built around a standard off-the-shelf LDR (Low Dynamic Range) sensor and a Virtex 6 FPGA board. This smart camera called HDR-ARtiSt (High Dynamic Range Adaptive Real-time Smart camera) is able to produce a real-time HDR live video color stream by recording and combining multiple acquisitions of the same scene while varying the exposure time. This technique appears as one of the most appropriate and cheapest solution to enhance the dynamic range of real-life environments. HDR-ARtiSt embeds real-time multiple captures, HDR processing, data display and transfer of a HDR color video for a full sensor resolution (1280 × 1024 pixels) at 60 frames per second.

The main contributions of this work are: (1) Multiple Exposure Control (MEC) dedicated to the smart image capture from the sensor with alternating three exposure times that are dynamically evaluated from frame to frame, (2) Multi-streaming Memory Management Unit (MMMU) dedicated to the memory read/write operations of the three parallel video streams, corresponding to the different exposure times, (3) HRD creating by combining the video streams using a specific hardware version of the Devebec'stechnique, and (4) Global Tone Mapping (GTM) of the HDR scene for display on a standard LCD monitor.

Abstract 2 (500 words)

Standard cameras capture only a fraction of the information that is visible to the human visual system. This is specifically true for natural scenes including areas of low and high illumination due to transitions between sunlit and shaded areas. When capturing such a scene, many cameras are unable to store the full Dynamic Range (DR) resulting in low quality video where details are concealed in shadows or washed out by sunlight. The imaging technique that can overcome this problem is called HDR (High Dynamic Range) imaging.

This paper describes a complete smart camera built around a standard off-the-shelf LDR (Low Dynamic Range) sensor and a Virtex 6 FPGA board. This smart camera called HDR-ARtiSt (High Dynamic Range Adaptive Real-time Smart camera) is able to produce a real-time HDR live video color stream by recording and combining multiple acquisitions of the same scene while varying the exposure time. This technique appears as one of the most appropriate and cheapest solution to enhance the dynamic range of real-life environments. HDR-ARtiSt embeds real-time multiple captures, HDR processing, data display and transfer of a HDR color video for a full sensor resolution (1280 × 1024 pixels) at 60 frames per second.The hardware implementation on the Virtex 6 shows relatively low hardware resources occupation(about 17% of the device) and a maximum frequency of 125 MHz.

The main contributions of this work are:

(1) Multiple Exposure Control (MEC) dedicated to the smart image capture from the sensor with alternating three exposure times. The MEC evaluates dynamically the adequate exposure times from frame to frame using the histograms and the number of low-level and high-level saturatedpixels of each captured frame. Exposure times are evaluated according the following principle: fewer than 10% of the pixels must be saturated at high-level for the short exposure time (respectively at low-level for the long exposure time). If too many pixels are saturated, the exposure time is decreased for the subsequent short exposure captures (respectively increased for the long exposures). Finally, the middle exposure time is linearly computed from the two other exposures.

(2) Multi-streaming Memory Management Unit (MMMU) dedicated to the memory read/write operations of the three parallel video streams, corresponding to the different exposure times. This MMMU continuously manages the storage of 3frames, the oldest frame being systematically replaced with the new acquired frame. The MMMU is able to capture and store the current stream of pixels from the sensor, and delivers simultaneous 2 pixel streams previously stored to the HDR creating process. With such a memory management,we avoid waiting for the capturing of new 3 frames before computing any new HDR data. Once the initialization is done, our system is synchronized with the sensor framerate (i.e. 60 fps) and is able to produce a new HDR frame for each new capture.

(3) HRD creating by combining the video streams using a specific hardware version of the

Devebec’stechnique, and Global Tone Mapping (GTM) of the HDR scene for display on a standard LCD monitor.