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Real-time Image Signal Processor Stats Management to Save Power and CPU Cycles

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Real-time Image Signal Processor Stats Management to Save Power and CPU Cycles

Abstract:

This publication describes techniques and apparatuses, implemented on a digital image capture device, directed at minimizing power consumption and central processing unit (CPU) cycles during image capture and processing events. An image sensor on the device captures a scene as a frame and generates raw image data. An on-device image signal processor (ISP) receives the raw image data and generates a statistics output ("stats output") that includes image statistics for the frame. The stats output further includes a descriptive tag for the image statistics, saved in a header of the stats output. Software implemented on the device (*e.g.*, a Statistics Manager) receives the stats output, parses the descriptive tag from the header, compares the descriptive tag to one or more previous descriptive tags, and determines if a change in the stats output is greater than a threshold. Upon determining that the change in the stats output is less than the threshold, the Statistics Manager determines that processing of the stats output by an Image Processing Module (*e.g.*, 3A algorithms, other ISP software algorithms) is not necessary. Upon determining that the change in the stats output is greater than the threshold, the Statistics Manager determines processing of the stats output by the Image Processing Module is necessary. Through the use of such techniques and apparatuses, an image capture device can avoid unnecessary processing of stats outputs.

Keywords:

Automatic focus (AF), automatic white balance (AWB), automatic exposure (AE), 3A algorithms, imaging device, camera, image processing, frame, image signal processor (ISP), software, image data, image statistics, threshold, header, power-intensive, central processing unit (CPU) cycling

Background:

Digital image capture devices (*e.g.*, cameras, smartphones, tablets) are configured for capturing scenes either as individual images or as a video. These devices utilize algorithms (*e.g.*, 3A algorithms, other algorithms), executed by an image signal processor (ISP), to automatically improve image quality through adjustment of image-processing settings. To accomplish this, components and software of such a device cooperatively operate to: 1) capture, by an image sensor, a scene as consecutive images (frames); 2) generate, by an ISP, a stats output (*e.g.*, pixel value data, a histogram of tonal values, lumen data) for every frame; and 3) analyze, by a Statistics Manager (*e.g.*, software, algorithms) the stats output to determine changes to image-processing settings. As a result of the analysis, one or more processors adjust camera parameter settings (*e.g.*, automatic focus (AF), automatic exposure (AE)) and/or adjust software parameter settings (*e.g.*, automatic white balance (AWB)) to refine the captured frames. Since the algorithms analyze every frame, stats processing is often power-intensive and may require multiple central processing unit (CPU) cycles.

Description:

This publication describes techniques and apparatuses, implemented on a digital image capture device (*e.g.*, smartphone, digital camera), directed at minimizing power consumption and CPU cycles during image capture and processing events. Figure 1 illustrates an example digital image capture device and components utilized to execute the techniques and apparatuses.

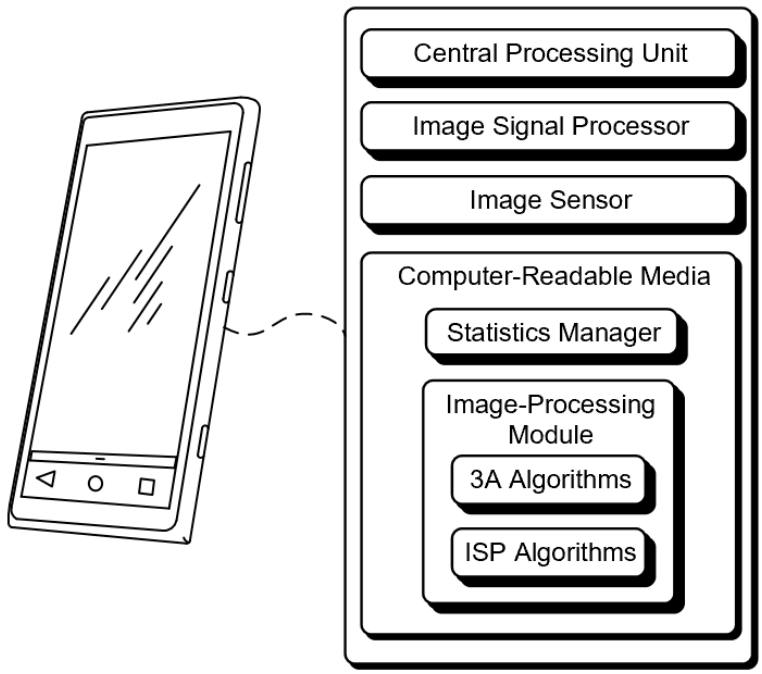

Figure 1

As illustrated, a digital image capture device includes a central processing unit (CPU), an image signal processor (ISP), an image sensor, and a computer-readable medium (CRM). The CRM stores executable instructions of a Statistics Manager and an Image-Processing Module that, responsive to execution by the ISP, implement the described techniques. The Image-Processing Module includes software algorithms (*e.g.*, 3A algorithms, other ISP algorithms) that process image data from the image sensor. The device performs operations under the direction of the Statistics Manager to compare image data of consecutive frames and determine similitude. The operations include receiving a statistics output ("stats output") from the ISP, parsing a descriptive tag from the stats output, comparing the descriptive tag to one or more previous descriptive tags from earlier frames, determining if the similarity in the tags is less than a threshold, and, if less than the threshold, instructing the ISP to skip execution of the Image-Processing Module so the device can minimize power consumption and CPU cycles.

During an image capture and processing event, the device, focuses scenic lighting on an image sensor. The image sensor detects the light and converts it to an electronic image signal (*e.g.*, analog signal, digital signal), for example raw image data. The ISP then processes the signal to form a digital image (frame). The ISP receives the image signal and carries out one or more image processing operations on the raw image data to generate a stats output. For example, the ISP may collect image statistics from and/or about the raw image data. Such image statistics can include statistical information relating to one or more of image data characteristics, information relating to image configuration, information relating to picture-taking conditions, information relating to scenic lighting, sharpness maps, information relating to automatic exposure, automatic focus, automatic white balance, brightness, black level compensation, flicker detection, histograms, object of interest detection information, spatial statistics, thumbnail information, and the like. Through the image statistics, the Image Processing Module (*e.g.*, 3A algorithms, other ISP software algorithms) implemented on the device understands the scene captured by the image sensor.

The ISP further generates a descriptive tag for one or more of the image statistics and saves the descriptive tag in the stats output. For example, the ISP may save the descriptive tag in the stats output as a field (*e.g.*, 32-bit, 64-bit) in the output header. Figure 2, below, illustrates a descriptive tag assigned in a header of a stats output.

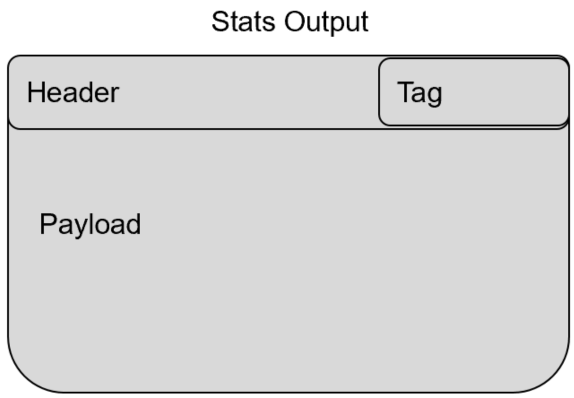

Figure 2

As illustrated, the stats output generated by the ISP includes a header and a payload. The payload contains the image statistics for the given frame. The header includes identifying information, for example, a frame number, a stats type identifier, a version number, and the like. The header also includes a descriptive tag. In aspects, the descriptive tag may contain image statistics from specified regions of interest (*e.g.*, location in a two-dimensional grid), a comprehensive analysis of the image statistics (*e.g.*, an average of all the pixels in the frame), or a combination thereof.

The Statistics Manager receives the stats output from the ISP, parses the descriptive tag from the header, compares the descriptive tag to one or more previous descriptive tags from earlier frames, and determines if the descriptive tag indicates a change in the stats output greater than a threshold. For example, the Statistics Manager may compare tags of a previous stats output and a successive stats output to determine a difference that exceeds a threshold. By comparing the consecutive tags, the Statistics Manager operates at this stage as a minimum difference detector, analyzing the image statistics contained in the tags to determine frame similitude. If the frames are similar and thus do not exceed a predetermined threshold, then further processing of the stats output by the Image Processing Module is unnecessary. By limiting stats output processing, the

Statistics Manager inhibits excessive stats processing while still maintaining excellent image quality. If, on the other hand, the Statistics Manager computes a difference between the tags that exceeds the threshold, then further processing of the stats output by the Image Processing Module to adjust image-processing settings is necessary and, as a result, permitted.

Additional benefits of such an approach include minimizing power consumption and required CPU cycles. For example, an image capture device capable of capturing 30 frames per second captures two consecutive frames nearly 34 milliseconds apart. The ISP of the device receives raw image data from the image sensor, generates a stats output including image statistics and a descriptive tag, and outputs the same as a stats output for each frame as the device captures them. A Statistics Manager implemented on the device then compares tags from multiple frames to determine frame similarity. If the tags indicate that the frames are similar (*e.g.*, that the frames contain identical scenic lighting), then the Statistics Manager indicates that further stats processing of the latest frame by the Image Processing Module is not necessary, since, for example, the previous stats output contains sufficient lighting information to appropriately adjust image-processing settings. Therefore, by reducing stats processing, the device minimizes power consumption and minimizes CPU cycling.

Operations of ISP algorithms may also be expedited through the addition of the Statistics Manager. For example, tone-mapping algorithms, or other interpolating algorithms, may benefit from the ISP software inhibiting the further analysis of similar frames, since repetitive image statistics may slow interpolation attempts. Moreover, lens color shading correction algorithms may benefit because the Statistics Manager can prevent the algorithms from processing similar payloads, and thereby assist temporal filtering (*e.g.*, the attenuation of undesirable signals).