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Edward Chang
Boyd Fowler

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SYSTEM AND METHOD FOR CAMERA CHARACTERIZATION

ABSTRACT

A system and method for camera characterization using a conventional monitor display is disclosed. The system is configured to display a pattern on the monitor and instructs the user to position the camera to capture the images displayed on the monitor. The captured images are analyzed by a software application in the computer that outputs camera characterization data used to improve quality of the images. The disclosure provides an efficient way for camera characterization without use of sophisticated equipment and provides a way to improve quality of images from an image processing perspective.

BACKGROUND

Camera characterization is an essential element of measuring overall imaging system performance. The characterization is required for reducing various imperfections in the images, including sensor defect pixels, structured noise, random noise, lens shading, color response differences, and optical distortion. In addition, system sharpness is characterized to compare different cameras or measure unit to unit variation. The current technology for characterization is in-factory calibration during manufacture of a camera. The implementation of this calibration process is expensive, and camera characteristics can drift over time, rendering the original calibration inaccurate. Further, users may lack the specialized equipment required for calibrating the cameras after purchase. Therefore, many cameras are left uncalibrated or miscalibrated, and as a result, they have reduced image quality. This disclosure provides an efficient way for
camera characterization and provides a way to improve quality of images from an image processing perspective.

DESCRIPTION

A system and method for camera characterization using a conventional monitor display is disclosed. The system is configured to display a pattern on the monitor and instructs the user to position the camera to capture the images displayed on the monitor. The captured images are analyzed by software in the computer and provide camera characterization data.

A system for camera characterization using a conventional monitor display is shown in FIG. 1 that includes hardware and software. The hardware is a monitor, a processor and an image capturing device. In one aspect, the image capturing device is a camera and the processor is a computer, laptop, smart phone, tablet or any other image processing device. The camera is wired or wirelessly connected to the processor and focused towards the monitor.

A method for camera characterization using a conventional monitor display is shown in FIG. 2. The software could reside on the tablet or mobile telephone or any other system used for image processing. It is configured to display a pattern on the monitor and instructs the user to position the camera for capturing images displayed on the monitor. The captured images are saved as raw data, downloaded to the computer, and transferred to the software for analysis. The analysis provides camera characterization data which could be saved in the computer, the camera device, or the cloud. The characterization data is used to improve the quality of the image captured from the camera.
FIG. 1: System for camera characterization
In one aspect, dark noise, pixels defect, structured noise, and lens shading of an image are measured in an uncalibrated monitor and flat field. The user has to connect the camera to a computer and start calibration software on the computer. Then, the user starts the calibration application in the camera and selects "white field calibration" in the computer software. The software instructs the user to dim the light in the room. The software instructs the monitor to display a box and the user to place the camera in the box on the screen against the monitor. As the camera is focused against the monitor, all images will be out-of-focus and blurred. The
blurring will cause uniform fields to be extremely uniform. Then, the user operates the camera application control to capture a dark image in raw data format. Immediately, the software displays a white screen on the monitor. The computer software commands the camera application to capture a light image in raw data format. The camera application and computer software work together to transfer the captured images from the camera to the computer.

The software analyzes the image by calculating the average dark image. If the average is high, the software instructs the user to dim the lights further and recapture the images. The software provides dark noise value by calculating the standard deviation of the dark image. The software identifies hot pixels defects by searching the dark image for outliers. The software calculates the fast Fourier transform (FFT) of the dark image and searches the fast Fourier transform (FFT) for peaks to indicate the structured noise in the image. The software could identify the dead pixel defects by searching the light image for outliers. The software is configured to filter the sample of the light image and provide a lens shading map of the image. The analysis provides data on dark noise, pixels defects, structured noise, and lens shading which are recorded.

In one application of the system, sensor full-well capacity and random noise are measured using a calibrated monitor and a time sequence of monochrome fields. The camera is placed directly against the monitor screen. The software displays a time sequence of uniform fields of gray, increasing in brightness over time. For example, initially the screen is black. After a second, the screen is dark gray (16 out of 255 brightness levels). After another one second, the screen is lighter gray (32 out of 255 brightness levels), and so forth. The previously measured or
calibrated values by the monitor could be compared against the camera responses and used to calculate the listed metrics.

In another example, color response is measured using a calibrated monitor and a time sequence of color fields. The camera is placed directly against the monitor screen. The monitor displays a time sequence of uniform fields of various colors by the instruction of the software. For example, the monitor may display a full screen of red, followed by a full screen of green, followed by a full screen of blue. The previously measured or calibrated values by the monitor could be compared against the camera responses and used to calibrate the camera color response.

In another instance, focused optical tests are used, whereby optical distortion, sharpness, digital sharpening, moire or demosaic errors, chromatic aberration and haze are measured. The camera is placed at some distance from the monitor, which allows the camera to focus on the screen. The software is configured to display a calibration pattern on the monitor and instructs the user to position camera for capturing images displayed on the monitor. The software also controls the camera shutter and capture images continuously to find the best image for characterization. For measuring optical distortion, users could find it difficult to hold the camera at an exact position relative to the monitor, so the software will detect and apply keystone correction to compensate. For measuring sharpness, the software could instruct the user to move the camera farther back until the display patterns exceed the angular resolution of the camera system. Then, various resolution chart patterns could be displayed for the camera to capture an image. In addition, examination of the pattern edges by the software could reveal the amount of digital sharpening done by the camera image signal processor (ISP). The software may also show
errors which result from demosaic algorithms. For measuring chromatic aberration, the monitor could display thick lines with sharp edges, and the software could identify and measure color fringing on both sides of the lines. For measuring haze—which indicates lens cleanliness and damage—the software could calculate the sharpness and contrast across the entire image for each capture. The sharpness and chromatic aberration could be measured across separate parts of the camera’s field of view and compared.

The disclosed characterization method is performed by the end user using a computer with a standard monitor. By implementing this system, the user can improve the image quality results from any camera application.