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# Camera Sensor Exposure Control During Camera Launch

**Abstract:**

This publication describes systems and techniques directed at fusing spectral-sensor data to drive the exposure control during the boot-up of a camera sensor on an electronic device. Fusing this data into the calibration of the camera during boot-up may significantly improve the execution time of the exposure control algorithm that ensures exposure readiness. In addition, since the exposure is critical to the focus-finding algorithm, these techniques may improve overall capture readiness times. By shortening the camera boot-up time, the camera is ready sooner to capture images, making a user less likely to miss capturing desired moments due to the camera not being ready as the moment occurs.

**Keywords:**

Auto-Exposure (AE), exposure control, imaging device, camera, image-processing pipeline, frame, camera boot-up, luminosity, lux, camera application, sensor, spectral sensor, algorithm, 3A control

**Background:**

In order to use a camera sensor equipped on an electronic device to take a digital image, a user launches a camera application. The camera application turns on the camera sensor and initiates a camera boot-up process. Once the boot-up process is complete, the user can use the camera to capture images.

The boot-up process calibrates the camera sensor by executing steps and algorithms, referred to as a pipeline, that optimize parameters of the camera, including exposure control and focus. An example pipeline is illustrated in Figure 1. Since the camera settings have no prior knowledge of the environmental conditions of the scene, the exposure control algorithm typically starts with a preset value for the exposure control parameter. The algorithm analyzes a sample image of the scene and adjusts the parameter value. The algorithm reiterates until the parameter value converges to an optimal level based on environmental conditions of the scene being captured. Calibrating the exposure control is responsible for a significant portion of the total boot time of the camera. The calibration ensures a well-exposed image is generated for the user.

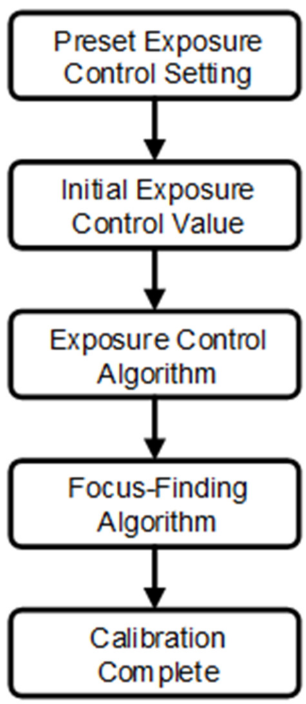


**Figure 1**

Conditions of the environment may prolong the calibration process. For example, if the environmental brightness is extremely low or extremely high, the exposure calibration may require additional iterations, further delaying the user from initiating the capture of an image. The faster the calibration happens, the sooner a user is able to capture a desired moment.

**Description:**

This publication describes systems and techniques directed at fusing spectral-sensor data to drive the exposure control during the boot-up of a camera sensor on an electronic device. Fusing this data into the calibration of the camera during boot-up may significantly improve the execution time of the exposure control algorithm that ensures exposure readiness. In addition, since the exposure is critical to the focus-finding algorithm, these techniques may improve overall capture readiness times. By shortening the camera boot-up time, the camera is ready sooner to capture images, making a user less likely to miss capturing desired moments due to the camera not being ready as the moment occurs.

Electronic devices equipped with a camera sensor include, but are not limited to, smartphones, digital cameras, and tablets. These electronic devices include at least one processor having logic for executing instructions, at least one spectral sensor, and a display for displaying a user interface. Spectral sensors constantly measure the luminosity of the environment by detecting the full lighting spectrum (*e.g.*, red-green-blue light (RGB), clear light (C), infrared light (IR)) of the environment. Spectral sensors, commonly located on the front and rear of the device, are used to adjust the brightness level of device displays as the environmental luminosity changes.

The devices also include a computer-readable medium (CRM). The CRM may include any suitable memory or storage device such as random-access memory (RAM), static RAM (SRAM), dynamic RAM (DRAM), non-volatile RAM (NVRAM), read-only memory (ROM), or Flash memory. The CRM includes a Camera Manager. The Camera Manager may be part of an operating system executing on the computing device. In other aspects, the Camera Manager may be a separate component (*e.g.*, an application) executing within an application environment or "framework" provided by the operating system.

The electronic device performs operations under the direction of the Camera Manager to turn on a camera and initiate a boot-up process. The boot-up process includes several steps, or pipeline, that calibrate the camera and ready it for image capture. These steps include receiving input from one or more spectral sensors, setting the initial exposure control parameter based on the spectral sensor(s) input, executing an exposure control algorithm, executing a focus-finding algorithm, and ultimately calibrating the camera. The focus-finding algorithm may be dependent on the exposure control and cannot execute until an optimal exposure control level is set. Figure 2 illustrates the calibration pipeline, relevant to this publication, followed during boot-up. There may be additional steps or algorithms dependent on the camera specifications.

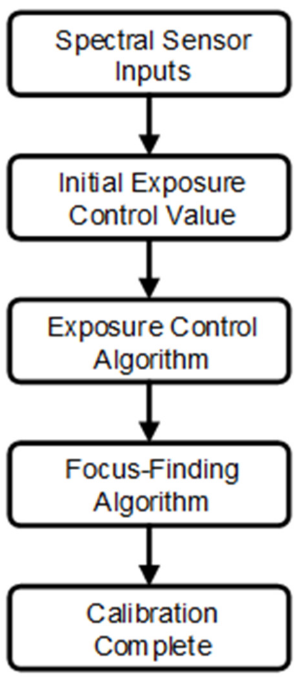


**Figure 2**

The exposure control algorithm uses the spectral sensor input as its initial exposure control value. The initial exposure control now more accurately aligns with the true brightness of the environment. The camera samples a first image frame based on this dynamically set exposure control. The exposure control algorithm may need to adjust and analyze additional image frames, but because the initial exposure control value started closer to the optimal value, the execution time of the algorithm may be sharply reduced.

Spectral sensors are already being used for other features, including display adjustment and will not cause extra power or computing usage. Dynamically setting the initial exposure control parameter may drastically reduce total boot-up time of the camera, allowing the camera to be ready to capture images sooner. The quicker boot-up time provides the user with a better experience in camera capture.

**References:**

[1] Patent Publication: US20140009639A1. Camera Control System, Mobile Device Having the System, and Camera Control Method. Priority Date: July 9, 2012.

[2] Patent Publication: US20150156388A1. Integrated Light Sensor for Dynamic Exposure Adjustment. Priority Date: December 18, 2012.

[3] Jinglun Gao, Szepo Robert Hung, Ruben Velarde, and Gang Sun. "Scene Metering and Exposure Control for Enhancing High Dynamic Range Imaging." Technical Disclosure Commons. Date of Publication: April 1, 2020. https://www.tdcommons.org/dpubs_series/3092.