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Improving Autofocus Speed in Macrophotography Applications

Dmitrii Boiarshinov

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Abstract:

This publication describes systems and techniques directed at improving the speed and accuracy at which an image capture device focuses on a subject in a macrophotography application. In some aspects, the image capture device may have a macrophotography mode, a proximity sensor, and an autofocus optical system. The autofocus optical system may be configured to determine if the image capture device is in a video/photo mode and use the proximity sensor to detect a subject in the field of view (FOV) of the image capture device. Responsive to determining that the image capture device is in a video/photo mode and detecting the subject in the FOV of the image capture device, the autofocus optical system may direct the image capture device to enable the macrophotography mode and/or drive one or more focusing elements to specific position intervals. By so doing, the autofocus optical system enables the image capture device, via the macrophotography mode and the proximity sensor, to focus on a subject more quickly and accurately in macrophotography applications.

Keywords:

Digital camera, digital photography, photography, smartphone camera, image capture device, autofocus (AF) optical system, focus, focal length, focusing elements, macro mode, macro imaging, macro lens, macrophotography, proximity sensor, range sensor, infrared sensor, depth of field (DOF), field of view (FOV), zoom lens, lens

Background:

Macrophotography is a popular and effective way to observe a subject in detail by producing an image of the subject that is larger than life size. For example, an entomologist may wish to study an eye of an insect to understand how the insect sees in low-light environments, reacts more quickly than humans to visual stimuli, or focuses on multiple subjects simultaneously. By utilizing macrophotography to capture a larger-than-life-size image of the eye of the insect, the entomologist may study the eye of the insect in detail, discerning minutia of the eye, potentially leading the entomologist to a greater understanding of the eye of the insect.

To capture an image of the eye of the insect using macrophotography, the entomologist may utilize an image capture device (e.g., a digital single-lens reflex (DSLR) camera, a smartphone camera) having an autofocus optical system. The entomologist may point the image capture device at the eye of the insect from a relatively close distance (e.g., 0.5 meters), engage and wait for the autofocus optical system to focus on the eye of the insect, and finally, capture the larger-than-life-size image of the eye of the insect.

However, the autofocus optical system may be slow to focus on the eye of the insect, forcing the entomologist to wait while the autofocus optical system hunts for focus. In some situations, the autofocus hunting process may be expedited by the entomologist moving the image capture device towards and away from the eye of the insect. In other situations, the image capture device may have a macrophotography mode that the entomologist needs to switch to manually. Any one of these situations can be time-consuming and frustrating for the entomologist, or any user of an image capture device, in a macrophotography application.

Description:

This publication describes systems and techniques, implemented on an image capture device (e.g., a digital single-lens reflex (DSLR) camera, a smartphone camera, a video camera), directed at improving the speed and accuracy at which the image capture device focuses on a subject in a macrophotography application. In an implementation, the image capture device may have a macrophotography mode, a proximity sensor (e.g., a doppler effect proximity sensor, an optical proximity sensor, a radar proximity sensor), and an autofocus optical system configured to expedite focusing on a subject in a macrophotography application. The image capture device may include one or more processors, an input/output device (e.g., a display, a viewfinder), and a computer-readable medium (CRM) for storing device data (e.g., user data, application(s), an operating system).

The processor(s) may be configured to execute instructions or commands stored on the CRM to implement an autofocus optical system configured to expedite focusing on a subject in a macrophotography application by activating the proximity sensor, controlling a lens displacement, processing signals, and triggering a switch to a macrophotography mode. The macrophotography mode may be implemented in the image capture device as software stored as instructions on the CRM, hardware, or any combination thereof. The hardware (e.g., a macro lens, a camera flash) may be located anywhere in or on the image capture device, such as within a housing of the image capture device, attached to the outside of the housing of the image capture device, and so forth. The proximity sensor of the image capture device may be a variety of proximity sensors, including, but not limited to, capacitive proximity sensors, doppler effect proximity sensors, electromagnetic proximity sensors, radar proximity sensors, and so forth. The proximity sensor may also be located anywhere in or on the device, such as within the housing of the image capture device or attached to the outside of the housing of the image capture device.

In an implementation, the proximity sensor is a laser proximity sensor and the image capture device is a smartphone having a camera module, a macrophotography mode, and an autofocus optical system, stored as instructions on the CRM to be executed by the one or more processor(s), configured to expedite focusing in macrophotography applications. The camera module may include a camera flash, a telephoto lens, a macro lens, one or more image sensors (e.g., dual pixel autofocus (AF) sensor, phase-detection AF sensor), a motor for controlling lens displacement, and the like. In this example, the camera module and the proximity sensor are attached to the back of the housing of the smartphone and the autofocus optical system is stored as instructions on the CRM of the smartphone, executed by the processor(s). Figure 1 illustrates the smartphone having the camera module and the laser proximity sensor attached to the back of the housing of the smartphone.

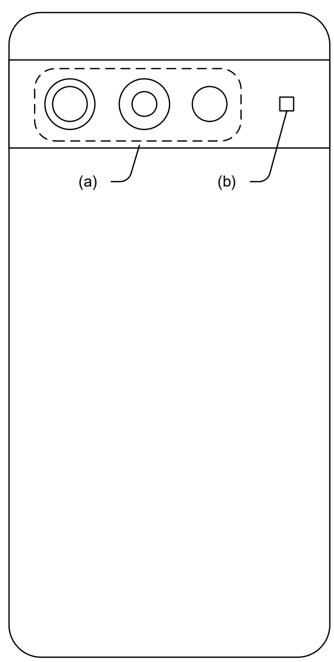

Figure 1. Smartphone having a camera module (a) and a laser proximity sensor (b).

In a macrophotography application, a user may direct the smartphone to enter a video/photo mode via a user input (e.g., a touchscreen), then point the smartphone at a subject from a relatively close distance (e.g., 0.5 meters). The autofocus optical system determines if the smartphone is in a video/photo mode. After determining that the smartphone is in a photo/video mode, the autofocus optical system detects, using the laser proximity sensor, the subject in the field of view (FOV) of the camera module. Responsive to determining that the smartphone is in a video/photo mode and detecting the subject in the FOV of the camera module, the autofocus optical system directs the camera module to hunt for focus by driving one or more focusing elements (e.g., using a motor) in the camera module to a specific interval of positions. The specific interval may be determined, for example, by a measurement output of the laser proximity sensor. For the sake of clarity, assume the capabilities of the laser proximity sensor result in three distinct measurement output values: “far,” “near,” and “in between.” Also, for the sake of clarity, assume the achievable interval of positions by the camera module are equivalent to 1 millimeter (mm) to 4 mm. If the measurement output of the laser proximity sensor is “near,” then the autofocus optical system directs the motor of the camera module to drive the focusing element(s) to the 1 mm to 2 mm range in an attempt to focus the subject more quickly. On the other hand, if the measurement output of the laser proximity sensor is “far,” then the autofocus optical system directs the motor of the camera module to drive the focusing element(s) to the 3 mm to 4 mm range in an attempt to focus the subject more quickly. Alternatively, if the measurement output of the laser proximity sensor is “in between,” then the autofocus optical system directs the motor of the camera module to drive the focusing element(s) to the 2 mm to 3 mm range in an attempt to focus the subject more quickly. Figure 2 illustrates this concept.

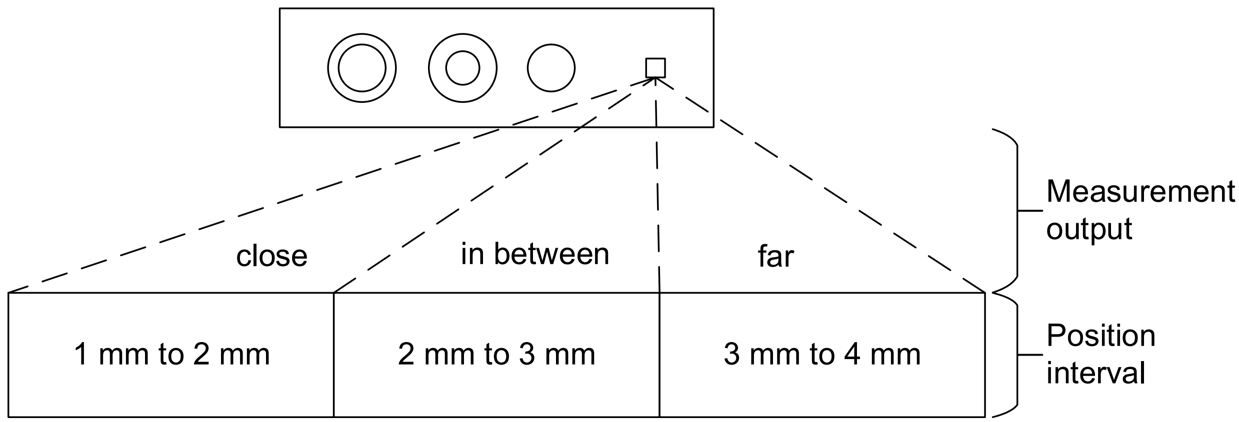

Figure 2. Focusing element(s) position intervals based on laser proximity sensor measurement output.

The autofocus optical system may direct the smartphone to enter the macrophotography mode, which may enable additional tools or features useful for macrophotography applications. The autofocus optical system may also direct the motor of the camera module to drive the one or more focusing elements to more appropriate position intervals for focusing on a subject that is near to the camera module. Alternatively, or additionally, the autofocus optical system may direct the camera module to switch to a more appropriate focal length, depending on the distance from the camera module to the subject. For example, many smartphones include a camera application and a camera module with both a telephoto lens and a macro lens. The camera application may include a telephotography mode, to be used in conjunction with the telephoto lens and its possible focusing element(s) positions and focal lengths. The camera application may additionally include a macrophotography mode, to be used in conjunction with the macro lens and its possible focusing element(s) positions and focal lengths. The driving the one or more focusing elements to specific position intervals, the entering of the macrophotography mode, and the switching to a more appropriate focal length, via directives of the autofocus optical system, may be enabled or disabled by the user.

In addition to the measurement output of the laser proximity sensor, the autofocus optical system may estimate a distance to the subject by using one or more cameras and associated image sensors in the camera module, focus position of the subject in a viewfinder, and a color of the subject. For example, if the subject is an eye of an insect that is mostly black in color, the autofocus optical system may estimate that the subject is far away from the smartphone if the color is mostly not black. Alternatively, the autofocus optical system may estimate that the subject is near to the smartphone if the color is mostly black.

Although this publication describes systems and techniques directed at improving the speed and accuracy at which a smartphone having a laser proximity sensor and an autofocus optical system focuses on a subject in a macrophotography application, the image capture device may be a variety of image capture devices. Furthermore, the proximity sensor may be a variety of proximity sensors, enabling a variety of measurement outputs and potential autofocus optical system features. Additionally, the photography application may be a variety of photography applications, not only a macrophotography application.

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