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Stable auto focus re-triggering with hand shake motion compensation

Ruiduo Yang

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ABSTRACT

Automatic focusing by a camera involves actively scanning possible lens positions and choosing one that provides the sharpest image. Triggering too frequently can result in image frames captured during the process leading to an out-of-focus image. On the other hand, triggering less often can also lead to an out-of-focus image due to changes in the scene being captured that occur after automatic focus was locked. Scene changes due to hand shaking or camera motion are typically not taken into account by the automatic focusing process. As a result, any such changes that occur after locking focus can result in an out-of-focus image.

This disclosure describes techniques that take into account camera motion during the automatic focusing procedures. The techniques involve analyzing camera motion to estimate if it can result in a change that requires refocusing by triggering the automatic focus process. If so, the automatic focus process is triggered to adjust the previously locked focus.

KEYWORDS

- automatic focus
- autofocus (AF)
- smartphone camera
- handheld camera
- camera motion
- camera motion
- focus triggering
- auto re-focus

BACKGROUND

Many cameras include functionality to focus the lens automatically prior to capturing an image or video. Automatic focusing includes actively scanning possible lens positions and choosing one that provides the sharpest image. Deciding when to trigger the auto focus functionality is an important step in the process. Triggering too frequently can result in image frames captured during the process leading to an out-of-focus image. On the other hand, triggering less often can also lead to an out-of-focus image due to changes in the scene being captured that occur after automatic focus was locked.

Shaking of the photographer's hand that holds the camera can cause camera motion that results in changes in the scene that is being captured, such as the detected Region Of Interest (ROI), change in camera position, etc. Such changes require corresponding changes in focus. However, scene changes that occur due to hand shakes or camera motion are typically not taken into account by the automatic focusing process. As a result, any such changes that occur after focus is automatically locked can result in an out-of-focus image.

DESCRIPTION

This disclosure describes techniques to consider camera motion due to the shake of the photographer's hands as part of the automatic focusing procedures for cameras. The techniques can be implemented for any camera, e.g., smartphone cameras, wearable device cameras, etc.

The techniques involve analyzing camera motion to estimate if it can result in a change that requires refocusing by triggering the automatic focus process. For instance, if the subject being captured is stable on the ground at some horizontal distance from the camera, hand shakes vertical to the ground do not affect the subject's horizontal distance from the camera. In such cases, no adjustments to the automatically locked focus are necessary despite the hand shake

motion, and the automatic focus procedure is not triggered. On the other hand, if the direction of hand shake results in a change in the ROI or the scene, the automatic focus process is triggered to accommodate the changes.

With the user's permission, camera motion is detected using the inertial measurement unit (IMU) of the user device that contains the camera. The decision to re-trigger automatic focus is made based on the direction of the motion in relation to the plane of the image being captured. Adjustments to automatically locked focus are triggered if any component of the camera motion is perpendicular to the plane of the image focus plane. In such a case, the focus is adjusted to account for the camera motion, e.g., that occurs due to the shaking of the photographer's hands.

For each completed auto-focus process (AF), an ROI position (p_0), an internal image state (I_0), and an IMU state (M_0) is recorded, with the user's permission. If the user permits, the recordings are used to determine an AF/ROI motion vector - V_0 = (x_0, y_0, z_0) - of the user device that includes the camera. For subsequent frames after the focus is automatically locked, internal image state (I_f) and IMU state (M_f) are recorded and registered to I_0 and M_0 to determine a global motion vector (V_1 = (x, y, z)) of the user device. The registration process can be done with the IMU state, with the image, or with both the IMU measurements and the image. The AF/ROI motion vector (V_0) is compensated with the global motion vector (V_1) and the compensated depth value is compared with the ROI position (p_0).

If the comparison indicates that the compensated depth value has resulted in significant change in the ROI position such that the ROI is off the currently locked focal plane, the automatic focus process is triggered to adjust the focus to account for the change.

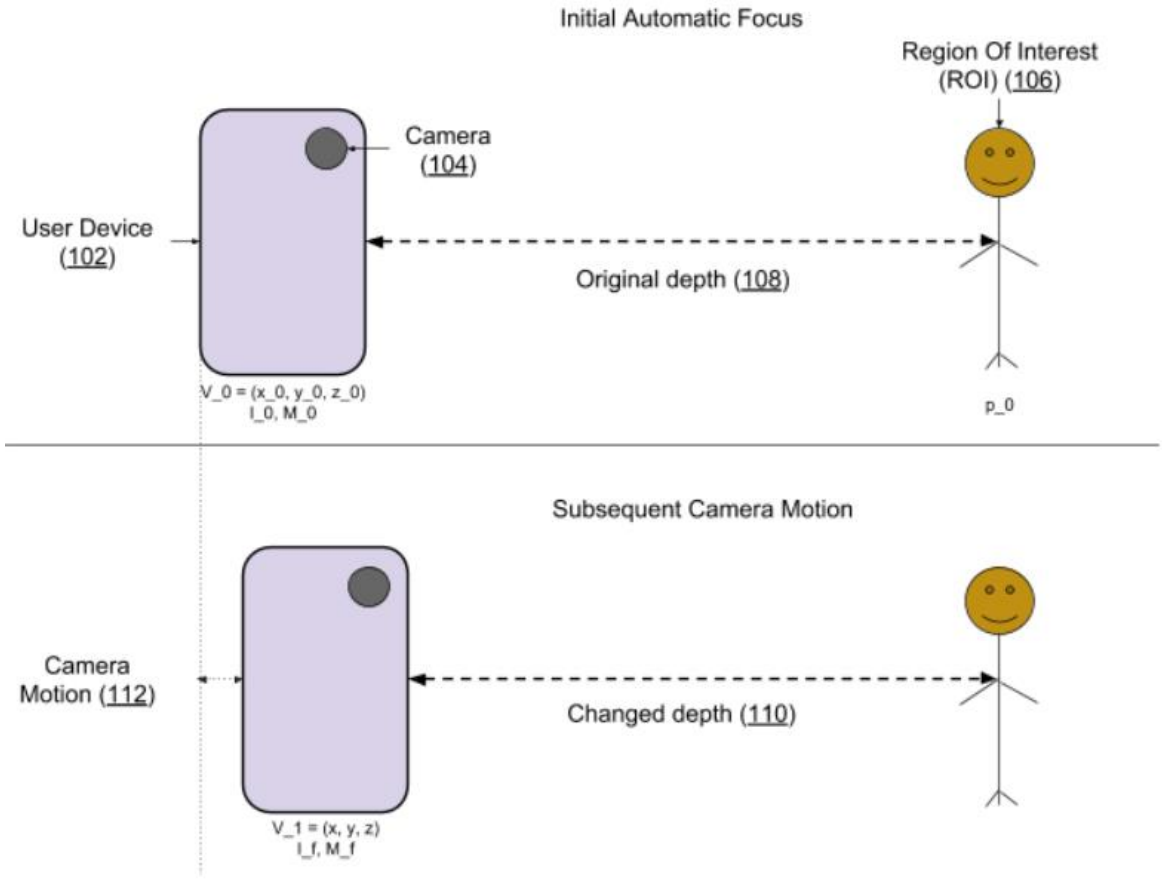

Fig. 1: Triggering adjustment to automatic focus to compensate for camera motion

Fig. 1 illustrates an operational example of the techniques of this disclosure. A user attempts to take a photo of the ROI (106) with a camera (104) in a user device (102). As shown in the top half of Fig. 1, the automatic focus is triggered and focus is locked with the camera at a distance of the original depth (108) from the ROI.

With the user's permission, ROI position (p_0), internal image state (I_0), and IMU state (M_0) are recorded along with an AF/ROI motion vector (V_0 = x_0, y_0, z_0). Subsequently, as shown in the bottom half of Fig. 1, the camera position shifts as a result of camera motion (112), e.g., due to shaking of the user's hands, which results in a distance between the camera and a reduction in the ROI to the changed depth (110). This change in depth is captured by comparing the global motion vector (V_1 = (x, y, z)) of the device captured along with the

updated internal image state (I_f) and updated IMU state (M_f). Since the camera motion results in a change that requires adjustments to the originally locked focus, the automatic focus process is triggered to adjust focus to the changed depth.

The described procedures optimize the triggering of the automatic focus functionality such that unnecessary triggering is reduced, thereby eliminating unnecessary battery use. At the same time, the procedures ensure that automatic focus is triggered appropriately to compensate for camera motion, such as that resulting from the shake of the photographer's hands, and enable a sharp image to be captured.

CONCLUSION

This disclosure describes techniques that take into account camera motion during the automatic focusing procedures. The techniques involve analyzing camera motion to estimate if it can result in a change that requires refocusing by triggering the automatic focus process. If so, the automatic focus process is triggered to adjust the previously locked focus. The described procedures optimize the triggering of the automatic focus functionality such that unnecessary triggering is reduced, thereby eliminating unnecessary battery use. At the same time, the procedures ensure that automatic focus is triggered appropriately to compensate for camera motion, such as that resulting from the shake of the photographer's hands, and enable a sharp image to be captured.