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Techniques and Apparatuses for Variable-Display Devices to Capture Screen-Fitting Images with a Maximized Field of View

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Abstract:

This publication describes techniques and apparatuses, implemented on variable-display devices (*e.g.*, foldable devices, laptops, multi-display devices), directed at capturing screen-fitting still images or video streams with a maximized photographic field of view, regardless of display size and device orientation. In aspects, a variable-display device utilizing a square image sensor with a diagonal greater or equal in size to the diameter of an image circle (*e.g.*, the cross-section of the scenic light focused on an image sensor by means of one or more lenses) enables the device to crop to the usual photographic and video aspect ratios (*e.g.*, 4:3, 16:9).

Keywords:

Aspect ratio (4:3, 16:9), image sensor, electronic imaging system, lens image circle, field of view, device orientation, foldable display device, image capture device, variable display, landscape mode, portrait mode, black bar padding, letterbox, pillarbox, crop, zoom, photography, pixel data

Background:

Image capture devices (*e.g.*, cameras, smartphones, tablets) utilize a technique where an image sensor is geometrically similar to a display of the device. For example, an image sensor in an image capture device may be geometrically similar in shape and aspect ratio (*e.g.*, 4:3, 16:9) to a rectangular display of the device. As a result of the geometric similarity, when the image sensor captures a scene as an image, the image capture device previews the image ("preview image") on the display with little wasted space, regardless of device orientation.

Figure 1 illustrates an image capture device, with a display and image sensor that are geometrically similar, in two different orientations.

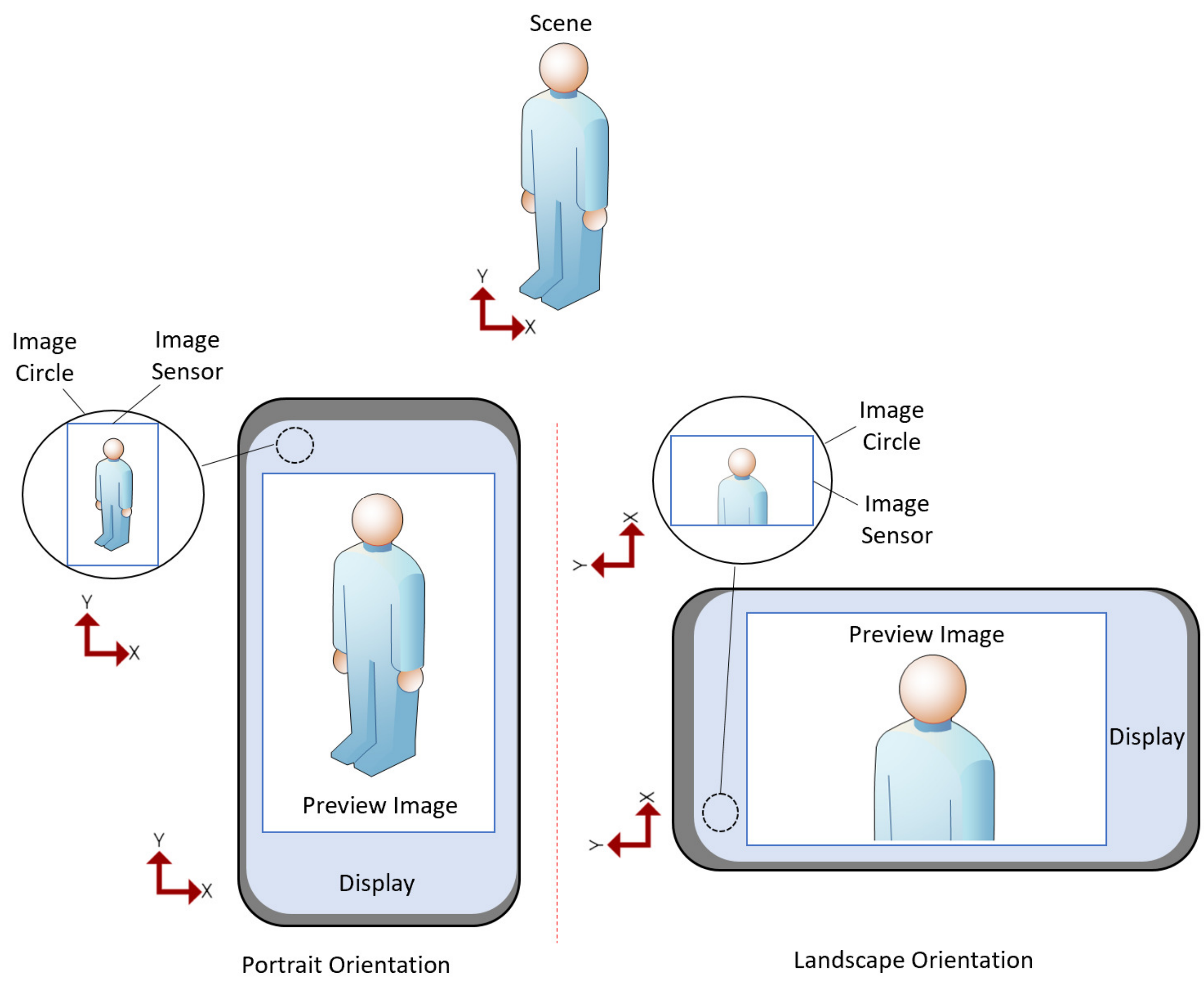

Figure 1

As illustrated in Figure 1, the same image capture device is positioned in two different orientations: landscape and portrait. In both cases, on the backside of the device, one lens focuses scenic lighting on an image sensor. The cross-section of the focused light transmitted by the lens(es) is referred to as an image circle. The image sensor then captures an image of the scene, and the device presents the image as a preview image on a rectangular display. Since the aspect ratio of the image sensor is geometrically similar to the aspect ratio of the display, the device can fit a preview image on the display with little wasted space, regardless of device orientation.

Such a technique, however, may not be as effective in variable-display devices (*e.g.*, laptops, foldable devices, devices with multi-display interfaces). Since the displays of such devices are not static in size and shape, in some configurations, a display may have a dissimilar aspect ratio to an image sensor. As a result, variable-display devices often employ additional techniques like black bar padding (*e.g.*, pillarbox, letterbox) or cropping and zooming to present a preview image that fits the display. Padding with black bars may be undesirable to users because the preview image does not fill the whole display. Cropping and zooming the preview image may also be undesirable because the field of view is reduced.

Description:

This publication describes techniques and apparatuses, implemented on variable-display devices (*e.g.*, foldable devices, laptops, multi-display devices), directed at capturing screen-fitting still images or video streams with a maximized photographic field of view, regardless of display size and device orientation. Figure 2 illustrates an example variable-display device and the apparatuses utilized to execute the techniques.

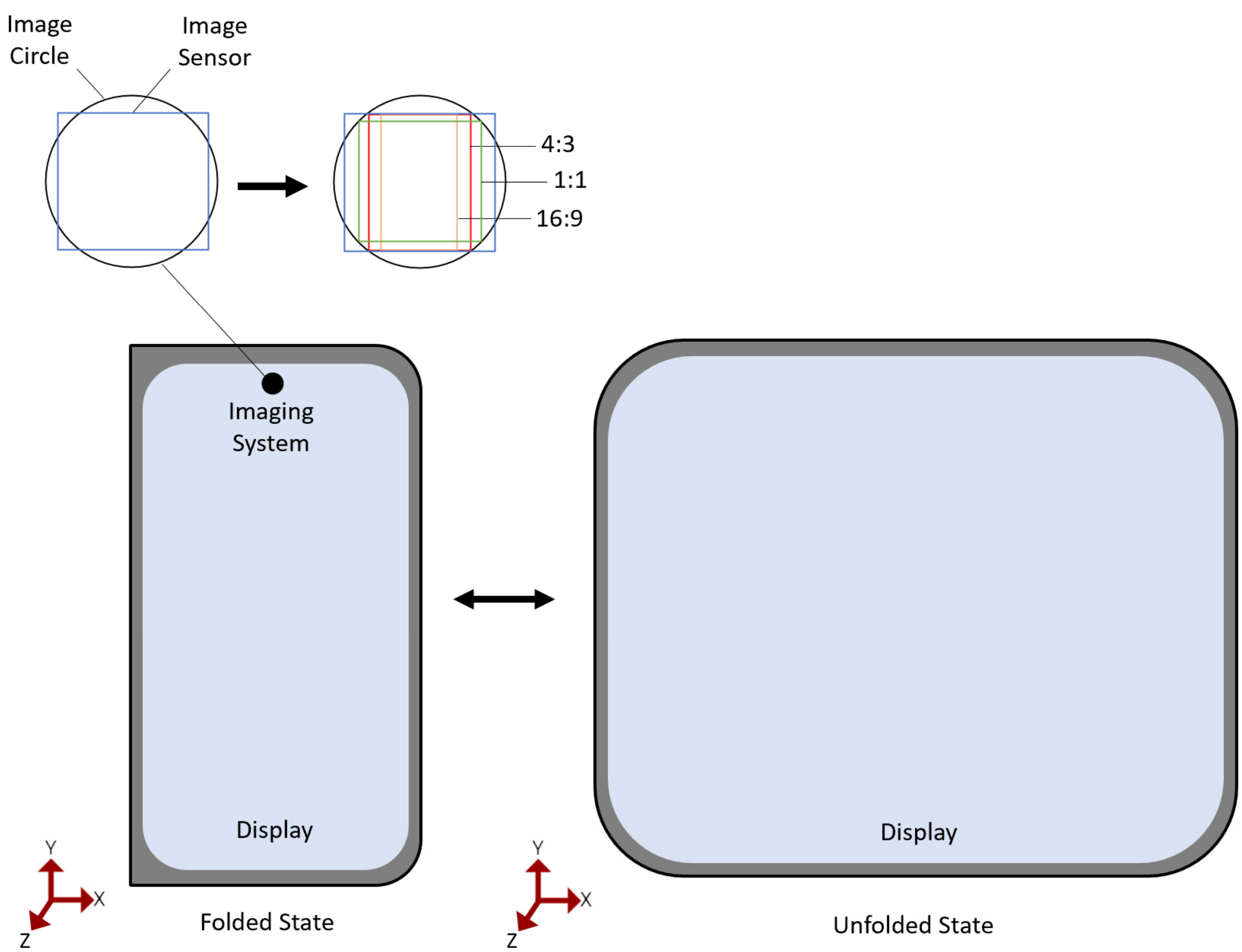

Figure 2

As illustrated in Figure 2, a variable-display device (*e.g.*, a foldable smartphone) is configured in two different states: folded and unfolded. The variable-display device includes two displays, namely, a display presented to the user in the folded state ("folded display") and a display exposed to the user in the unfolded state ("unfolded display"). The variable-display device also includes an imaging system (*e.g.*, camera). In the folded state, a front-facing imaging system is exposed pointing in the positive z-axis. While in the unfolded state, the same imaging system is on the backside of the device pointing in the negative z-axis. In the folded state, the folded display is oriented in a portrait orientation. In the unfolded state, the unfolded display is oriented in a landscape orientation.

The imaging system of the variable-display device includes a circular lens and an image sensor with a 1:1 aspect ratio (*e.g.*, ratio of width to height). The image sensor senses the cross-section of the focused light transmitted by the lens ("image circle") and generates an image of the scene. As illustrated in Figure 2, the imaging system is configured with a square image sensor whose diagonal is larger than the diameter of the image circle.

Utilizing such a configuration enables an imaging system to capture screen-fitting still images or video streams with a maximized photographic field of view, regardless of display size and device orientation. For example, if the imaging system of the variable-display device illustrated in Figure 2 captured an image while in the folded state, then the device can present the image on the display ("preview image") in the usual, portrait photographic aspects ratios (*e.g.*, 4:3 and 16:9). If, on the other hand, the same imaging system captured an image while in the unfolded state, then the device can present the preview image in the usual, landscape photographic aspects ratios. Since the image sensor is larger than the image circle, the imaging system can crop the preview image to be geometrically similar to any display aspect ratio, regardless of device orientation. By cropping the preview image to the desired aspect ratio, the preview image still retains a good field of view.

In other aspects, the imaging system can be configured with a rectangular image sensor with aspect ratios other than 1:1 that are compatible to achieve usual photographic and video aspect ratios in landscape or portrait modes. In this manner, if the variable-display device has certain, predictable display shapes for which it may fold and unfold into, then the image sensor can be sized or shaped to sense scenic lighting most conducive to presenting a preview image on the display(s).

In another aspect, the imaging system is configured with a square image sensor inscribed in the image circle. Figure 3, below, illustrates such a configuration.

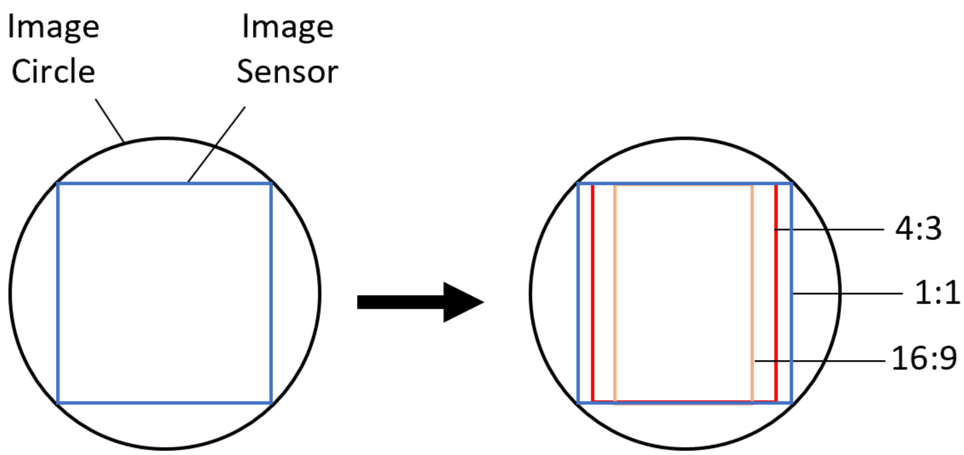

Figure 3

As illustrated, the square image sensor is inscribed in the image circle. In such a configuration, no regions of the image sensor are outside of the image circle and, as a result, all pixels of the image sensor are utilized. For example, a 10-megapixel square image sensor may otherwise image black if the sensor expanded beyond an image circle. If the image sensor is inscribed in the image circle, however, all pixels of the image sensor are employed to capture the scenic lighting. Utilizing such a configuration enables the imaging system to capture an image and crop the preview image to any aspect ratio in a portrait or landscape orientation. However, for display and sensor aspects ratios other than 1:1, preview images generated using this configuration may have a reduced field of view in comparison to preview images generated using the configuration as presented in Figure 2.

In any aspect, variable-display devices may also utilize lensless imaging systems to accomplish the disclosed techniques. For example, an image circle may be produced by the transmission of scenic lighting through a glass-covered hole onto an image sensor. As a result, a square image sensor with a diagonal greater or equal in size to the diameter of the image circle can still crop the preview image to any aspect ratio in a portrait or landscape orientation.

In conclusion, the disclosed techniques and apparatuses enable variable-display devices to capture screen-fitting still images or video streams with a maximized photographic field of view, regardless of display size and device orientation.

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