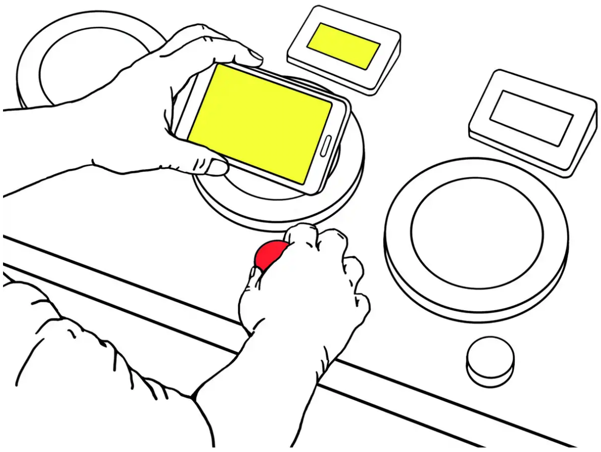
Capturing the invisible

Does your camera see the same things you see?



Turn on your smartphone camera.

Look at the LEDs and illuminated surfaces through the camera.

Try the individual experiments and observe what happens.

Your eyes and your smartphone camera perceive light or rather electromagnetic radiation differently. With your eyes, you can see visible light in different colours while infrared radiation is also “visible” to the smartphone camera.

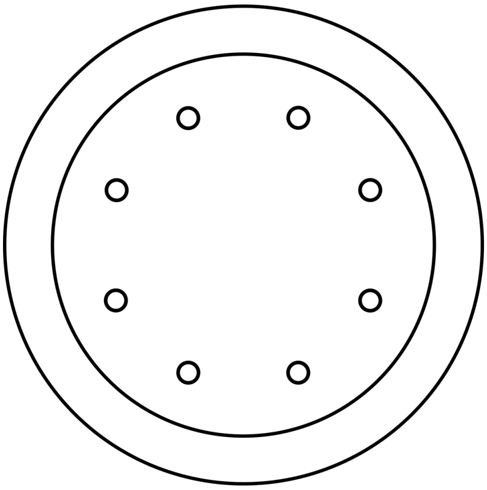
A camera sensor breaks down an image into a large number of pixels, which are read out one after the other when a photo is taken, or video is recorded and converted into image data. If an object moves or changes during the recording, it may look distorted, individual image elements may be missing or appear several times.

Experiments

LED circle

Look at the LED circle. What colours are the LEDs? Are they all lit?

Look at the LEDs through your smartphone camera and compare what you see and what the camera “sees”.



Your smartphone camera probably “saw” more than you. All LEDs are switched on and emit electromagnetic radiation or light. Your eyes only perceive a very small part of the electromagnetic spectrum: visible light (Fig. 1). Ultraviolet and infrared radiation are outside of the range of electromagnetic radiation that is visible to your eyes.

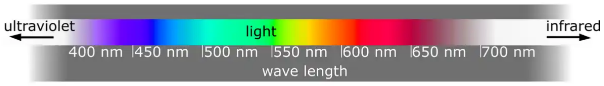
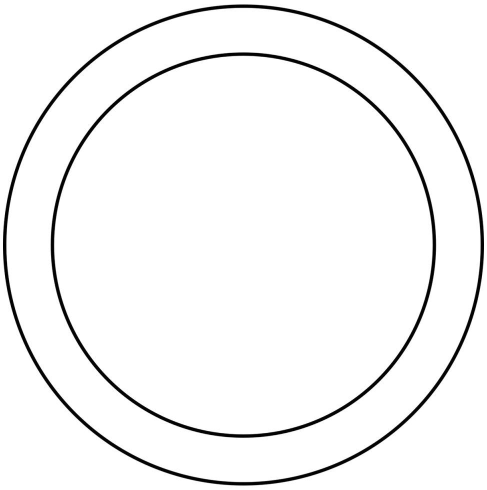


Fig. 1: The spectrum visible to the human eye (source: Horst Frank / Phrood / Anony, CC BY-SA 3.0 <http://creativecommons.org/licenses/by-sa/3.0/>, via Wikimedia Commons).

You can only see the two infrared LEDs (850 and 940 nm) lit through your camera, because your camera’s image sensor is also sensitive to infrared radiation. Therefore, you can use your smartphone camera, for example, to check whether the LED on a remote control is lit.

If the infrared LEDs are not lit in your camera image, your smartphone has a built-in infrared filter to avoid unwanted effects when taking photos. Compare your camera image with that of another smartphone. Not all smartphones have a built-in infrared filter.

Tri-colour LEDs



Hold your smartphone low over the matt flickering plexiglass disc and observe it through the camera.

Change the refresh rate with the rotary knob.

Do you see colourful stripes, discs, or rings that move across your camera image?

At which rate do you see a still image?

Under the matt plexiglass disc, there are LEDs lit in the three colours red, green, and blue. One by one, the individual LEDs are switched on and off again. This happens so quickly that the light from the LEDs appears white to the human eye. When the refresh rate, at which the LEDs are switched on and off, is low, you can see a flicker, which disappears at a higher refresh rate.

Your smartphone camera will show you something else: while your eyes perceive a rapid flicker at a low refresh rate, the LEDs in the camera image seem to be switched on and off again one by one much more slowly. This is a result of the so-called rolling shutter effect. The camera sensor captures an image line by line at a certain rate. When this so-called sampling rate matches the LEDs' refresh rate, you will see a still image. When the two rates only differ a little, a so-called beating occurs, causing coloured stripes to slowly move across the image. What does the image look like when the refresh rate is twice as high as the sampling rate? Take a look at other lights in your surroundings through the smartphone camera and test whether you can capture similar images there.

The rolling shutter effect also creates interesting photos of moving objects, such as a propeller airplane (Fig. 1): The propeller appears bent when the sampling rate of the image sensor is larger than the propeller's number of rotations per second. Fig. 2 illustrates the formation of the bent propeller.

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Fig. 1: Rolling shutter effect: The airplane's propeller in the photo appears in bizarre shapes because the sampling rate of the image sensor is either smaller (left) or larger (right) than the propeller's number of rotations per second. When the propeller rotates slowly on approach, it appears curved in the photo (left); when it rotates faster in cruise flight, it appears as lines in the photo (right).

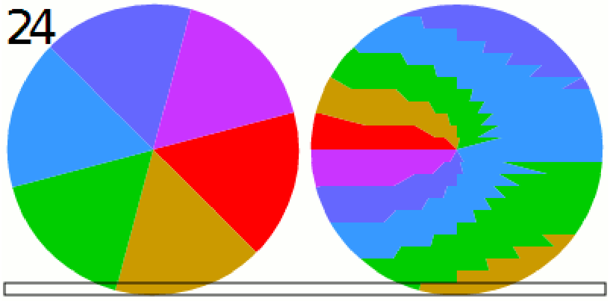

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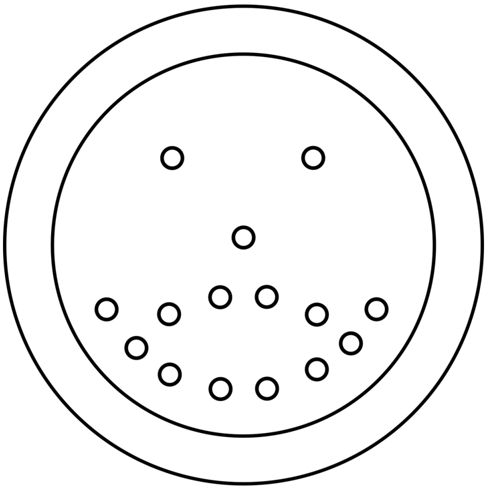
Fig. 2: Rolling shutter effect in a figure (right) of a colourful rotating wheel (left).

Happy or sad smiley face?

Hold your smartphone low and horizontally over the flickering smiley face and observe it through the camera.

Change the refresh rate with the rotary knob.

Can you adjust the rate so that the smiley face is happy?



One after the other, the LEDs are switched on and off again with a certain refresh rate. At the same time, the camera sensor takes a picture of the LEDs with a certain sampling rate. If the rates differ, you will alternately see a happy and a sad smiley face. The smaller the difference between the refresh rate and the sampling rate of the camera sensor, the slower the alternation between the smiley faces. If both rates are the same, then you will either see a happy, a sad, or a mixture of both smiley faces in the flashing LEDs. This is achieved at a frequency of approximately 30 Hz.