

### 3.4: Camera in a Smart Phone

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These can contain standard **double Gauss** or **Cook triplet** lenses and sometimes more advanced aspheres. The image sensor is CMOS. Nowadays smart phones have auto-focus systems where the lens is moved towards or away from the sensor using different criteria. In the standard contrast detection auto-focus the lens is moved until the contrast in the image is largest. This trial-and-error method is relatively slow: it usually takes 1 second to focus. In high-end cameras so-called phase detection auto-focus is used. The relative positions of two spots obtained from the focusing of two small diaphragms on either side of the optical axis is analysed. Depending on the relative positions of the spots, the lens is moved towards or away from the sensor. This auto-focus system is three times faster than the contrast-based system. The third method that is currently used is an active auto-focus system similar to radar. An infrared laser pulse is emitted and the distance of the object of interest is determined from the return time of the reflected pulse. This method is roughly as fast as the phase detection method. It works very well under low light conditions, but is not accurate for objects at distances of more than 5 m. In all smart phone cameras, blurry images are sharpened by post-processing using software.

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