



What is a Retina Display & what you need to know about PPI

A Retina Display does not match our retina resolution, but it serves as an excellent approximation



The Retina Display

The Retina Display was first introduced at an Apple event back in 2010. As Steve Jobs elaborated during the iPhone 4 event: The pixels become invisible to the human eye when you hold your device 10 or 12 inches away from your eyes and the pixel density exceeds 300 PPI (pixels per inch). Based on a simple calculation the statement can be explained as follows. When every pixel only counts for 1 arc-min (1/60 degrees) or less to your eyes, you will not see any individual pixels but a continuous surface.

In reality, that's only correct for some people, not all of us. When you hold your device 10 or 12 inches away from your eyes, sometimes you can still see individual pixels. That's because the angular resolution of our retinas is actually higher than 1 arc-min. Why did Steve Jobs then tell us that you cannot see individual pixels under these conditions? Because, except for marketing purposes, it is an excellent approximation for most people under most conditions.

Visual acuity is usually measured with a Snellen chart or a random E chart. A subject is asked to answer if he or she is capable of distinguishing the letter or the direction the letter E is facing. If the subject can distinguish it 20 feet away from the chart, he or she is considered to have 20/20 vision, and we usually consider that to be normal. If your visual acuity is measured to be less than 20/20, the doctor may ask you to consider buying prescription glasses.



A practical threshold

The reason why the Retina Display's definition is a good approximation is that the actual content we care about is nothing like the letters on the Snellen chart or the random E chart. Also, the viewing environment is often not as well lit as the doctor's examination room. If you are reading an article on your smartphone, each letter is composed of a great number of pixels to make it comfortable for reading. Even if you could distinguish each pixel in theory, you are less likely to see each pixel when the letters are composed of lots of pixels.

The human eye's ability to distinguish these details varies with different contrast. If the contrast of the letters is not high enough due to environmental lighting conditions, the human eye's visual acuity actually drops. If you use your smartphone outdoors, the sunlight is decreasing the contrast on your display due to the high reflection from the cover glass. Under these conditions, you are less likely to notice any pixels because of poor contrast.

Sometimes we use our smartphones for viewing pictures at e.g. Instagram, short clips from YouTube or movies from Netflix, the contrast of these content is much lower than black and white text. So you are less likely to notice any pixel. According to our experience in printed papers, 300 DPI (dots per inch) is considered to be just enough for most people. DPI in the printing business means almost the same as PPI in the display business. This means that 300 PPI is practically enough for most people in most conditions.

A simple rule of thumb

20/20 visual acuity is not the limitation of the human retina. But it is a good indicator for people to know what PPI is good enough for different products. For example, we use our smartphone 12 inches from us, so 300 PPI is just enough because 300 PPI at 12 inches meets the 20/20 visual acuity definition. If you only use your desktop monitor 16 inches away, we can quickly calculate the PPI you need for your desktop monitor. 16 inches divided by 12 inches is approximately 1.3, and 300 PPI divided by 1.3 is 230 PPI. Therefore the PPI you need for your desktop monitor would be 230 PPI which is similar to the Retina Display Apple claimed for their Macbook Pro products.

As for television, we often watch televisions 60 inches away, the PPI needed for television would be 60 PPI. A simple rule of thumb would be buying any TV with Full HD resolution / 32 inches in diagonal or less, or 4K-UHD resolution / 65 inches in diagonal or less. Although it is extremely unlikely that you are going to read any article, text, or email on your TV, it is not practical to have a 20/20 vision quality television.

Full HD is actually enough for almost all sizes of TVs. If you see any pixel on your TV while watching a movie, it is an indicator that you are sitting too close to the TV, and should move further away from the TV for the good of your eyes!

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