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**How to determine the resolution of an optical scanner**

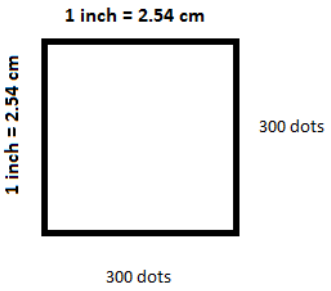
In the last issues of the FFE Journal many articles covered techniques to identify forged or genuine stamps. One of the main tools is an optical scanner. Usually users want to have an as high as possible resolution. Manufacturers of scanners usually advertise very high resolutions e.g. 4800 dpi interpolated. But what is the real resolution of a scanner that experts can use?

**What is meant by resolution?** [1]

It is the number of pixels a scanner can sample in an item. The resolution is measured in dpi meaning dots per inch. An ordinary scanner can resolve 600 dpi, that means 36 000 single pixels per square inch. In a centimetre scale that means 5580 single pixels per $cm^2$. The higher the resolution the more information you obtain and the more information you have to handle.

A scanner head moves along a page and each of its sensors gethers information, the more sensors the higher the resolution and the higher the price. The scanner head stops frequently along this movement. With 300 sensors per inch a scanner would have a resolution of 300 * 300 dpi. This is called **optical** resolution.

Additionally there is the so called interpolated resolution. Some manufacturers claim, that they can improve the resolution by in-serting new calculated real pixels between the actually measured pixels leading to more information and better images. On our example that would lead to a 600 * 600 dpi resolution. In reality this process reduces the quality of a scan for expertising purposes.




**How can I determine the real resolution of my scanner?**

In 1951 the US Air Force developed a method to determine the optical quality of optical imaging systems such as microscopes and cameras.[2] For this purpose the USAF 1951 chart was developed. This chart consists of about 50 groups of 3 lines, ranging from large to very small. If you scan this chart you can determine the group of lines which you just can resolve. [3]

The chart is organised in 7 groups of six elements. Each element consists of three horizontal and three vertical lines. Group 0 is the largest, group 7 is the smallest.

Let's look at an example.

I use an Epson Perfection V500 Photo scanner. Epson states a resolution of 6400 dpi. I scanned this chart with the maximal resolution of 6400 dpi, saved it in the .tiff format and analysed the scan in Adobe Photoshop at 100 % magnification.

The smallest groups of bars I could resolve were the horizontal bars of group 5 element 1 and the vertical bars of group 4 element 5. With the chart comes a table from which you can determine the resolution: In my case the horizontal resolution is 1626 dpi and the vertical resolution is 1290 dpi. This means I can use my scanner up to 1200 dpi, which is sufficient for almost all purposes on a large area. For higher resolutions of smaller areas of a stamp I use my microscope.

If you scan a stamp with a higher amount of resolution, than your scanner can optically resolve, you do not gain more information, but you have longer scanning and processing times. In the above mentioned example it means scanning with e.g. 2400 dpi, does not give more information.

This chart and the precise manual are available from www.scandig.com or can be borrowed from the author.

**Example on Belgian stamp**

The Belgian stamp 2cts from 1915 was scanned in three different resolutions. The right eye area (about 2 mm wide and 1.5 mm high) was magnified and enlarged to the same size.


The stamp size is 2.0 cm * 2.5 cm, it was scanned with Epson V500, and saved in *.jpg format

The enlarged cut outs of the scans with 300 dpi (left), 1200 dpi (middle), and 4800 dpi (right) are shown below. The left cut out shows only a poor resolution of the eye, the middle and the right cut outs show far better resolution and more details.

Even if you enlarge the middle and the right cut out even larger, there is the same amount of information in the pictures, there are no more details. The right scan shows smoother lines, which are generated by the interpolation routine of the scanner, but this smoothness is only calculated.

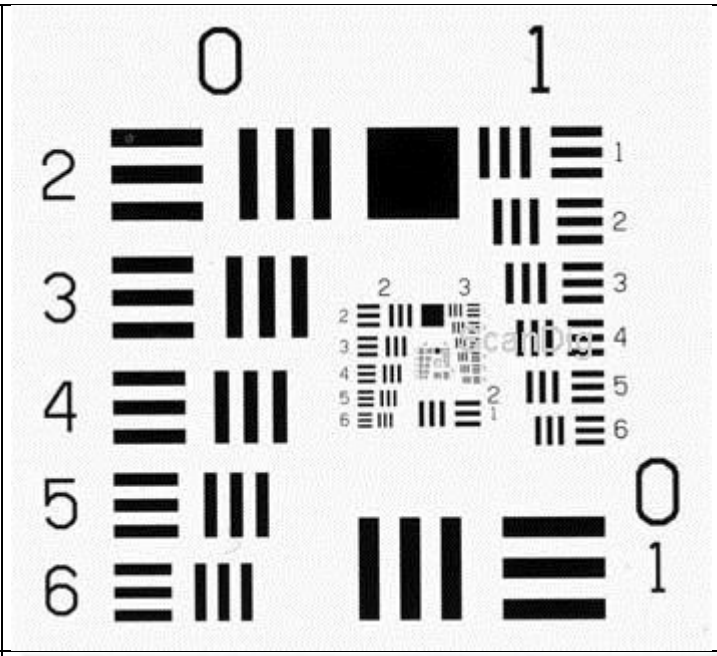
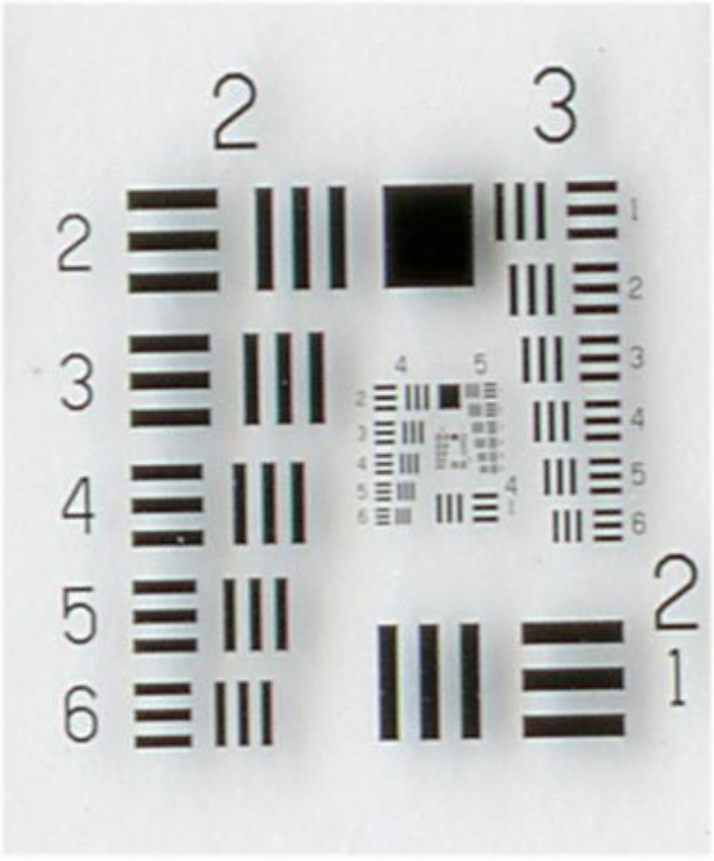
| Resolution | Scan time | File size |
|---|---:|---:|
| 300 dpi | 5 sec | 51 kb |
| 1200 dpi | 20 sec | 540 kb |
| 4800 dpi | 240 sec | 4500 kb |

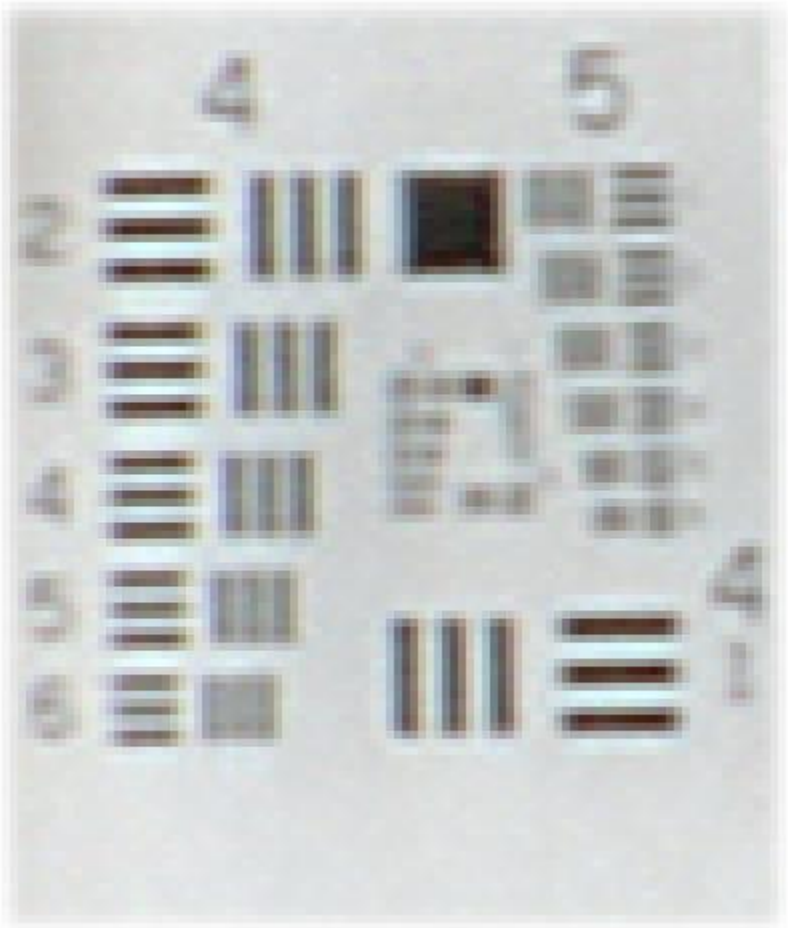
**Consequences**

The effective optical resolution of a scanner differs from the values given by the manufacturer of scanners. It is therefore reasonable to determine the optical resolution of a scanner. These values are usually not provided by the vendor.

In order to optimise processing times it is necessary to scan only with the maximal optical resolution of a scanner.

The optical resolution of a scanner can be determined with the USAF1951 chart.

| | |
|---|---|
| Full size scan of the USAF 1951 chart. One can see the different groups of six elements each. Each element consists of 3 vertical and three horizontal bars.<br><br>On the right lower corner one can see group 0 Element 1, on the left group 0 and the smaller elements 2 – 6. On the right upper corner group 1 elements 1-6 and so on. |  |
| Magnification of groups 2 – 7 with my scanner. |  |

| | |
|---|---|
| High magnification of groups 4-7. One can see the pixels of the scan. Group 4 element 6 shows still a good resolution of the three horizontal bars while the vertical bars can barely be resolved. Group 5 element 1 shows still some resolution of the three horizontal bars. |  |

| Group / Element | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| **1** | 51 | 102 | 203 | 406 | 813 | **1626** | 3251 | 6502 |
| **2** | 57 | 114 | 228 | 456 | 912 | 1825 | 3649 | 7299 |
| **3** | 64 | 128 | 256 | 512 | 1024 | 2048 | 4096 | 8193 |
| **4** | 72 | 144 | 287 | 575 | 1149 | 2299 | 4598 | 9196 |
| **5** | 81 | 161 | 323 | 645 | **1290** | 2580 | 5161 | 10322 |
| **6** | 91 | 181 | 362 | 724 | 1448 | 2896 | 5793 | 11586 |

Table which can be used to determine the resolution. The values are given in dpi.

[1] http://www.nuance.com/scannerguide/firsttimeusers/specifications/resolution.asp
[2] http://en.wikipedia.org/wiki/1951_USAF_resolution_test_chart
[3] http://www.filmscanner.info/en/Aufloesung.html