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INFLUENCE OF TEST CHART CONTRAST ON QUANTIFICATION OF PHOTO SHARPNESS

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Abstract: *Quality control of digital photos is evolving rapidly every day. Procedures and methods of measurement are changing. Cameras on mobile phones are currently in focus because they are largely replacing the cameras used so far. Based on the standards for the control of photos on mobile phones, in this paper one of the essential quality attributes was chosen to be tested, which is the sharpness of the photos. For the purposes of the experiment, five commercially available mobile phones with different rear camera characteristics were selected. Two standard test cards with different contrast ratios were used. The tests were carried out under appropriate laboratory conditions. Sharpness is analaziry via MTF50 value as measured in Imatest software. Based on the results, it is concluded that the contrast of the test chart affects the measured value, therefore it is important to strictly define the conditions of measurement and the used test card when analyzing this attribute.*

Key words: digital photography, mobile phone rear camera, sharpness, test chart contrast

1. INTRODUCTION

One of the important attributes of image quality is certainly sharpness, i.e. the possibility of reproducing fine high-frequency details. Sharpness (resolution) can be defined as the smallest interval measurable by a scientific (especially optical) instrument. Sharpness can be categorized as a local attribute. The appearance of local attributes depends on the viewing conditions with respect to viewing distance and size of the image (Phillips & Eliasson, 2018).
The measurement of sharpness is a measurement of the spatial frequency response (SFR). This function describes how well the system under test can reproduce a range of spatial frequencies (Figure 1) on a scale from 0% (complete loss of information) to 100% (perfect reproduction without data loss) (Image Engineering, 2022).

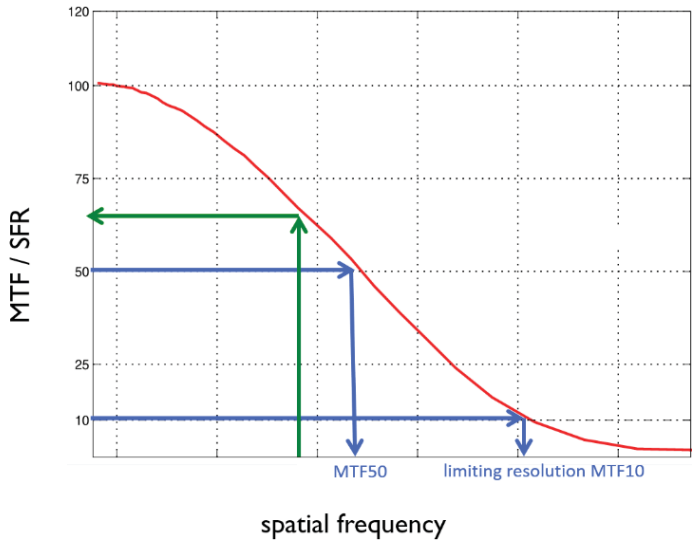

Figure 1: The X-Axis shows the spatial frequencies increasing from left to right, and the Y-Axis depicts the SFR (Image Engineering, 2022)

To measure sharpness in photos, we must first select a test chart. Quality control of photography devices, especially mobile phones, is in daily development, so test charts are also changing and developing constantly. One option is to use the Slanted Edge SFR measurement developed by Burns and Williams (2002) and standardized in ISO 12233 (ISO, 2017). In addition to the slanted edge, a method based on a Sinusoidal Siemens Star is also used which is evaluated on a radius by radius or frequency by frequency basis (Loebicha et al, 2007).
The old high-contrast ISO 12233 chart (Version 2000) is referenced in the ISO 12233:2000 standard but is no longer a part of the standard. It should only be used when results need to be compared with older work (Imatest, 2022).
The obsolete ISO 12233:2000 standard defines a resolution test target with a high contrast ratio. These are typically produced at the maximum dynamic range, which can be anywhere from 40:1 to 80:1. The high contrast can lead to clipping of the signal which leads to overstated invalid MTF values. Some camera manufacturers who want better MTF results may take advantage of this anomaly to overstate the quality of the cameras they produce (Imatest, 2021). The revision of the standard resulted in a new test card where the contrast was reduced to the level of ratio 4:1. New version of test chart should contain minimum 9 slanted squares for slanted edge measurements. The mentioned test charts are shown in the Method section, Figure 2.
The aim of this work is to measure the sharpness of the photo obtained with the rear camera on commercially available mobile phones, and to use two test chart (a high-contrast and a low-contrast), during the measurement. In the continuation of the paper, the experiment and the devices used are described in detail, after which the obtained results are presented and discussed.

2. METHODS

For the purposes of the experiment, 5 different phones were used, the specifications of which can be found in Table 1. In order to check the effect of contrast on the measured sharpness values, two test charts were chosen. The old high-contrast ISO 12233 chart (Figure 2 a) and low-contrast ISO 12233:2017 Edge SFR, eSFR (Figure 2 b). The experiment is carried out under suitable conditions in a darkened room. The only light source used was made for the purposes of the experiment. The stand on which the mobile phone is positioned in the middle, and on both sides at an angle of 45 degrees, there are LED lamps that simulate daylight (5000 K). The camera sensor is placed flush with the center of the test chart, while the distance of the stand is 70 cm from the chart. Photographed test charts were tested in Imatest software, module SFR. The ROI (Region of interest) area was the same for all phones (80 x 160 px). On the high-contrast test chart, 8 possible fields were measured, while on the low-contrast map it was possible to measure 15 different fields.

Table 1: Mobile phone camera specifications

Mobile phone	Aperture	Rear camera resolution
Samsung Galaxy A52s 5G	f/1.8	2400 x 1080 px / 64 MP
LG K10	f/2.2	720 x 1280 px / 13 MP
Huawei Mate 10 Lite	f/2.2	1080 x 2160 px / 16 MP
Apple iPhone 11 Max Pro	f/2.4	2688 x 1242 px / 12 MP
Xiaomi Redmi Note 10	f/1.9	1080 x 2400 px / 48 MP

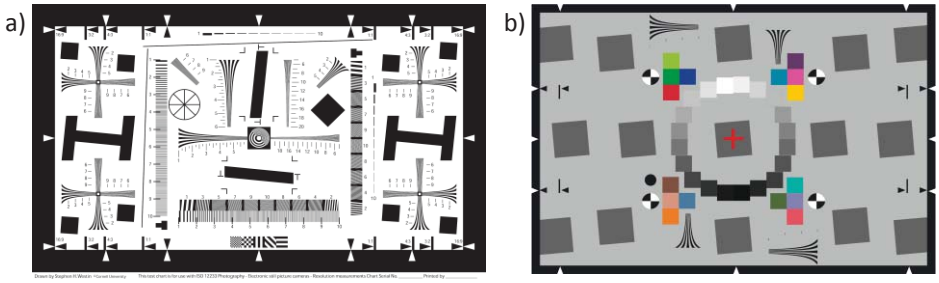

Figure 2: Test charts used in the experiment, a) high-contrast and b) low-contrast

3. RESULTS AND DISCUSSION

The obtained results are shown in Figures 3 and 4. The graph shows the mean values, as well as the minimum and maximum values for each phone. Based on the results, it can be concluded that the number of megapixels, i.e. the resolution of the camera certainly does not affect the quality of the obtained photo, in this case specifically the tested quality attribute - sharpness. Image processing has a much greater influence on the sharpness of the photo. The fourth phone with 12 MP has the highest sharpness when measured on the low-contrast test chart. The MTF50 value for that phone is much higher compared to phone 1 (64 MP) and phone 5 (48 MP). When measuring the old test card (high-contrast), slightly different results were obtained. In that case, the phone with the highest resolution (64 MP) has the highest MTF50 value. Higher values were also obtained during the control of phone 3, while similar results were obtained with the other phones when the test chart was changed.

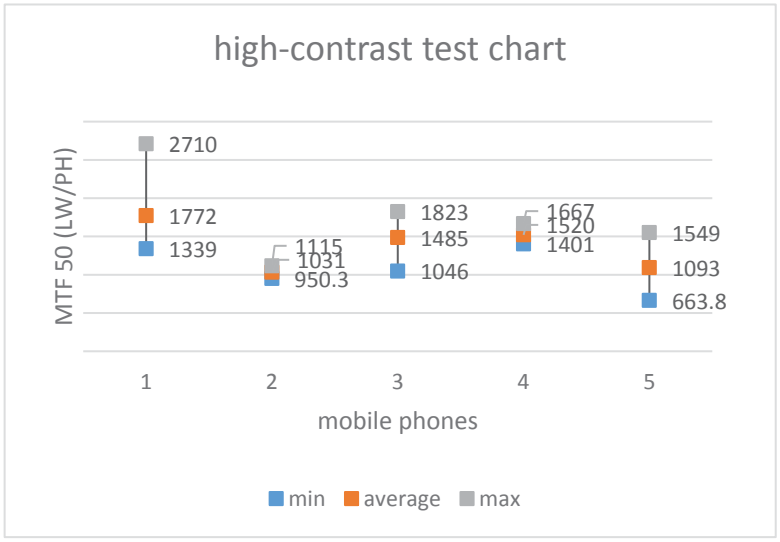

Figure 3: Measured sharpness (MTF50) for high-contrast test chart

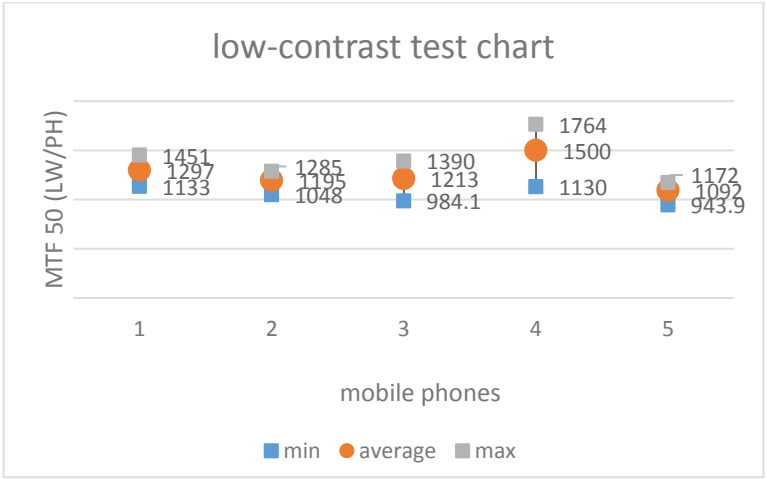

Figure 4: Measured sharpness (MTF50) for low-contrast test chart

Large variations of the measured sharpness at different positions of the test chart were also observed. In the corners of the test chart, the sharpness values decrease significantly. With phone 5, these variations are the most pronounced.

4. CONCLUSIONS

Cameras on mobile phones are already largely replacing semi-professional and even professional cameras in some segments. Therefore, years ago there was a need for a more serious control of the quality of the photos taken with both the rear and front cameras. There are many centers that provide customers with a detailed quality analysis, in addition to the basic specifications provided by the manufacturers. There is also a standard that deals with it, Camera Phone Image Quality (CPIQ). The CPIQ standard seeks to standardize image quality test metrics and methodologies across the industry, correlate objective test results with human perception, and combine this data into a meaningful consumer rating system. One of the important attributes is sharpness, which depends on the viewing distance and therefore belongs to the local group of quality attributes. Inadequate sharpness leads to more than low-quality images; it can also lead to dangerous situations, especially in security and automotive industries that often rely on high-sharpness images and video for safety and effectiveness. It is thus vital to properly test and analyze the image sharpness of the camera under test. In this paper, the influence of the contrast of the test chart on the value of the obtained sharpness was examined. Based on the results, it is concluded that the contrast has an impact. Depending on the selected test chart, different values were obtained. However, for more concrete analyses, a suggestion for future research is to consider a larger number of cameras, as well as a larger number of different contrast ratios on the test charts.

5. ACKNOWLEDGMENTS

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