A Framework for Applying Image Quality Metrics on Printed Images

Seyed Ali Amirshahi

Master CIMET, Gjøvik University College, Norway

ABSTRACT: In order to evaluate the performance of printers, plotters and other printing hardware we need to evaluate the printed output. One way to evaluate prints is by using image quality metrics. The first step to do so is to find a way to apply them. All image quality metrics need a digital image as their input. This makes transforming printed images to a digital format an important step for evaluating the quality of printed images. In this paper a new framework for applying image quality metrics on printed images is introduced. The framework takes a printed image in physical form as its input and gives a digital image ready to be used with different image quality metrics as its output. The frameworks gives out better and faster results compared to other frameworks.

1. INTRODUCTION: The output of a printer or any other printing hardware is a physical copy of the original image. This copy is different from the original image in many aspects which would affect the Image Quality (IQ) of the printed image compared to the original one. The first choice which passes through mind is using a subjective evaluation with the help of human observers, for doing so we will need to make subjective quality tests under certain controlled conditions which makes subjective tests time and resource consuming. Also we should expect that the human preference towards IQ might change over time. To avoid all these problems and have a standard metric for evaluating IQ we will have to use objective evaluation. Different methods for objective evaluation of IQ have been proposed. These methods, in terms of IQ metrics, could be categorized in three different groups, Full Reference (FR) metrics, Reduced Reference (RR) metrics, and No Reference (NR) metrics. Pedersen and Hardeberg List a number of used FR metrics [1].

Since both the original and the printed image are available when evaluating the performance of a printer, a FR method is used. In this case the original image is in a digital format and the printed image is in an analog format. For applying an objective metric we will need to transfer the printed image to a digital format. In this paper a new framework for transforming a printed image in a physical format to a digital image is introduced.

The paper is organized as follows: section 2 describes previous frameworks. In section 3 the new framework which is based on control points is introduced. Section 4 will consist of applying different IQ metrics. Finally the conclusion and further work which is planned to be done to improve the framework is mentioned in section 5.

2. PREVIOUS FRAMEWORKS: All previous frameworks follow the same three main steps. The procedure is shown in Figure 1. At first the printed image is scanned giving a digital image of the printed image. Then a descreening procedure is done on the digital image to remove the halftoning patterns. At the last step a registration is performed for matching the digital image with the original image.
Zhang et al. [2] introduced the first framework in 1997. In the framework the image is scanned four times with a resolution of 1200 dpi, once normally and three other times with three different color filters to transform the image into CIEXYZ. To test their results the S-CIELAB [3] IQ metric was used on the color patches as the testing image.

Yanfang et al. [4] proposed a new framework in 2008. In the framework two control points, one to the upper left and one to the upper center are added to help the registration and matching the scanned image to the original image. A resolution of 300dpi was used for the scanning step and descreening was done at 230 lpi. The S-CIELAB [3] IQ metric was also used to test the framework.

One of the most recent frameworks introduced was proposed by Eerola et al. [5]. The framework follows the steps shown in Figure 2. After scanning the printed image a descreening is applied on the original and the scanned image using a Gaussian low-pass filter. Unlike the previous framework this framework uses local features with a Scale-Invariant Feature Transform (SIFT) and then for finding the best matching points RANd SAmple Consensus principle (RANSAC) is used. Bicubic interpolation was used for scaling the image. The printed images were scanned at a 1250 dpi and the LAMBSE IQ metric was used to test the framework.

3. PROPOSED METHOD: The framework proposed uses four control points for the transformation process. The points are added to the corner of the printed image, as shown in the images in Figure 3. As it can be seen the control points are black squares. Figure 4 gives an overview of the steps taken in the framework. First we will pad the image with the four control points. Then the image is printed with a printing device. The printed image is then scanned and the profile of the scanner is used to get the best output from the scanner. During the scanning procedure the scanned image might be affected by scaling, rotation, translation and other geometrical distortions. To overcome this problem image registration is needed. The last step before applying IQ metrics is removing the padded dots. To prevent descreening twice in the whole IQ assessment (once during the framework and once when IQ metrics is applied) there is no descreening in the proposed framework.
During the scanning procedure the images were scanned with a resolution of 600 dpi. The original test images were a subset of 15 images used by Pedersen et al. [6, 7]. Two different profiles were used to process the original images and then the results were processed with four different software's resulting in a total of eight different images for each original image.

![Sample of padded images](image1.png)

(a)

![Sample of printed image](image2.png)

(b)

**Fig. 2 Sample of padded images.**

**Fig.4 Proposed framework.**

3.1 *Image registration:* The first step in the image registration procedure is transformation. For doing so, we must first find the coordinates of the center of the padded dots for both the original image and the scanned version of the printed image. For scaling the scanned image to the size of the original image we will need to do an interpolation as the last step in the registration procedure.

To select the best method among the possible methods for transformation and interpolation different combinations (15 in total, five different transformation and three different interpolation) where tested on different images which were rotated and rescaled to model possible errors made during scanning. After applying these combinations on the test image the Mean Square Error (MSE) between the registered image and the original image is calculated. Figures 5 and 6 show the result for the two images shown in Figure 3, keep in mind that the values are normalized by the highest value. As it can be seen a combination of “similarity” and “bilinear” will give the lowest MSE value.
3.2 Comparing the frameworks: Although adding control points to the image before printing is a disadvantage of using control points in a framework but comparing the framework with the frameworks which use local points still has advantages. Frameworks using local points have really bad results when they are applied on uniform images. Also the computational time of our framework is about 20 times faster than the framework which uses local points (Eerola et al. [5]).

4. IMAGE QUALITY METRICS: As was mentioned before no descreening was used in the framework leaving it for the IQ metrics. For evaluating the IQ of the printed images four different IQ metrics were used. S-CIELAB,
S-CIELAB\textsubscript{Johnson} [8], S-DEE [9] and SHAME [10] were the metrics used. Correlation coefficient between subjective score and objective score is calculated with values nearly equal to zero. This shows that the IQ metrics cannot follow the results of the objective tests.

5. FUTURE DIRECTIONS & CONCLUSION: In this paper a simple framework for assessing printed images has been proposed. The framework is based on using control points and is a modified version of previous frameworks. The framework is giving better and faster results compared to state of the art framework using local points. Keeping all these in mind the IQ metrics do not give good results on the overall quality although some of them give better results comparing to other IQ metrics.

Regarding the future work which is planned to be done, testing the effect of scanning resolution on the overall error is an important fact. We might see different outputs when we try the framework on different scanning resolution. Finding where the errors are and how to minimize the errors would be the next step.

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REFERENCES: