The QMark: A proposal for a new camera quality metric for consumer digital cameras

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Abstract

The explosive growth of digital photography has necessitated a convenient and simple quality metric that can be used to evaluate digital cameras. Several standards organisations are in the process of developing methods to measure specific parameters of digital camera image quality such as image resolution[1], spatial frequency response[1], speed[2], linearity and noise[3]. These objective image quality metrics are often used independently from subjective studies. In most cases, from the consumer's standpoint, the final "camera quality" is based on subjective opinions of popular publications. Consumers and industry alike do not have the means to determine the suitability of a camera for an application in an unbiased, reproducible way.

We propose a new quality metric - the QMark- based both on 'scientific' optical and electronic measurements, technology content, objective comparisons, *and* subjective evaluations of usability and usage models. Components, weighting factors and calculation methods for the Q-Mark will be discussed.

Introduction

The computer industry and users of computers have benefited by having developed specific standard methods to compare the processing power of computing engines. While no one method can provide a universal assessment of computational power for all users, standard tests like Linpack and SPECmark measure performance criteria like floating point speed, string handling ability, and integer unit speed. It is left to the user to determine their specific usage model and apply the relevant metrics.

With the introduction of more than 100 digital cameras models from dozens of vendors in the last 5 years, and sales in the millions world-wide, there is a need for a simple method of camera evaluation for the consumer. We have developed a method to evaluate and classify digital cameras, which is based on measurement of parameters which photography experts and camera designers have deemed critical to the success of digital photography. These parameters include:

- Resolution
- Colour fidelity
- Camera volume and weight
- Zoom range
- Ease of use
- Battery life
- Connectivity
- Removable media
- Colour review display
- Flash features and range
- Image authenticity
- Technological content.

Some of these parameters are objectively quantifiable, but others, like ease of use, are subjective and will change with time as camera architecture progresses.

The QMark Digital Camera Metric

The QMark is designed to measure three fundamental qualities of a digital camera: image quality, usage model, and technological content.

There are four 100-point QMarks: one each for image quality, peripheral applicability, 'consumer' camera applicability and technological content.

To score 100 QMark points for image quality, the camera would have to produce images with resolution and colour balance equal to or better than the best 35-mm cameras using ASA100 colour negative film. Some professional grade digital cameras costing $10,000 or more, like the Kodak DCS, series produce images that would score 90 or more QMark image points. Most digital cameras today, because of image artefacts and low resolution, score between 30 and 60 image quality QMark points.

The QMark for usage model is divided into two components because of the widely divergent nature of digital camera use. We see cameras used as computer peripherals, tethered to a personal computer platform and as stand-alone devices that are similar in use and function to film cameras.

The QMark for use as a computer peripheral measures the suitability of a camera for use as a computer add-on. A tethered camera with 30 frame per second video frame data transfer would score highly in this QMark. Primary elements for this component are the ability to sit conveniently on a desk and transmit data at high speed. It should be noted that several 'conventional' non-tethered

cameras score highly in this QMark because of their excellent connectivity.

The QMark consumer camera metric indicates the suitability of the camera for standard photographic tasks. Here the important factors are ease of use (a subjective measure based on comparison to film cameras), number of stored images, battery life, size, and availability of camera-like scene capture capability. A digital SLR, like the Olympus D-600L, would score highly on this QMark because of the excellent scene capture capability provided by the wide-range zoom lens, flexible light metering capability and reflex viewing system.

The QMark for technological content measures how much in the camera is “new” and “innovative". These innovations can be electronic, like the use of an embedded DRAM processor in the Fuji MX-700; optical, as the image stabiliser system in the Canon Optura; or at a system level, like the user interface in the Kodak DC200-210 cameras. Naturally as digital cameras evolve the term 'innovative' will change significantly. The four major engineering factors for digital cameras - integration, size, cost and amount of local storage - provide the majority of the scoring for this QMark.

There are between 3 and 7 components used to calculate the four QMarks. The general model for a component of an individual QMark is:

$$\text{Component} = w\ f(p),$$

where f(p) indicates that there is a functional relationship between the measured parameter, p, and the value used to calculate the component, and w is a weighting factor indicating the importance of the component to the QMark number. The functional relationship may be linear, non-linear or have a threshold. The functional form is somewhat arbitrary and is based on our observations and those in the industry of the sensitivity of consumers to the particular parameter.

As an example of linear dependency on a measured parameter, we present the pseudo-code for the resolution component of the imaging QMark as:

```
If lp < 1800 lw/ph
   Imaging = 50  lp / 1400,
Else
   Imaging = 50
End if
```

where lp is the measured line pairs per picture height resolution of the digital camera. We see that this metric has a weight of 50% out of the 100-point imaging QMark, and is linearly related to the resolving power of the best 35-mm film cameras. Since almost all photographic resolution requirements are met by the capabilities of present 35-mm film, we award no additional points for resolution higher than that provided by film.

In Figure 1, we present the price component model used in calculation of the technology QMark. This component has been designed to show the strong dependence of customer acceptance on price. Other QMark components have other non-linear or threshold dependencies on measured parameters.

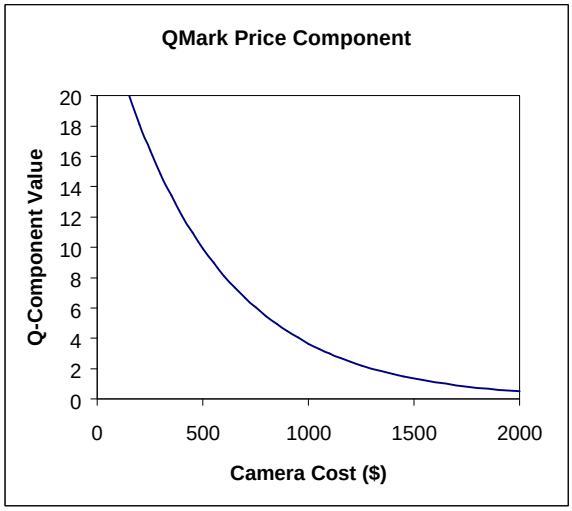

Figure 1: *The non-linear price component of the technology QMark. For this model, $500 is the price point required for customer acceptance.*

The subjective components of the QMark are awarded based on fixed, well-defined criteria that are repeatable from user-to-user. Camera features are also awarded QMark points where they differentiate novel use, new or advanced technology. The complete scoring procedure is lengthy and can be found in reference 4.

Discussion

To examine the utility of the QMark metric, we will compare two cameras, the Kodak DC210 digital still camera, and the Canon Optura Mini-DV digital video still camera. The QMark for these cameras are shown in Figure 2 and 3.

From virtually all standpoints, these are very different cameras. The Kodak DC210 is a megapixel still camera with superb image quality and the most user-friendly interface in the industry. The Canon Optura is an SLR-like digital still camera that has a wide range zoom lens, adjustable shutter and aperture, virtually unlimited storage of still images on its Mini-DV storage tape, but only limited image quality and resolution. The Optura has a 200 Mbit/second IEEE 1394 Firewire interface, NTSC composite and S-video outputs, which provide superb connectivity.

From a comparison of the QMark ratings, the image quality superiority of the Kodak camera is evident, as is the

advanced scene capture capability of the Canon Optura. Technologically, both cameras score nearly equally, the Kodak because of high integration, light weight and low cost, the Optura for its long battery life and large image storage capacity.

For the Peripheral Usage QMark, the Optura significantly outperforms the Kodak DC210 because of the availability of composite, S-video, and high speed (Firewire) transfer interfaces. With proper software, the Optura can stream video directly to the PC at video frame rates over the Firewire interface.

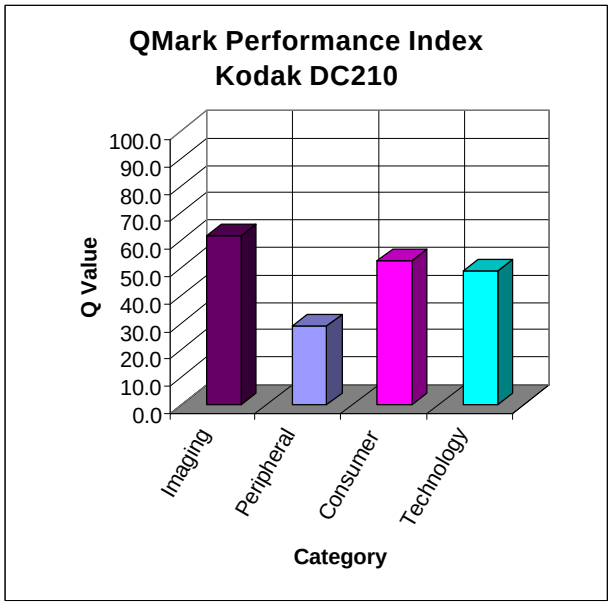

Figure 2: *The QMark, in graphical form, for the Kodak DC210 digital still camera*

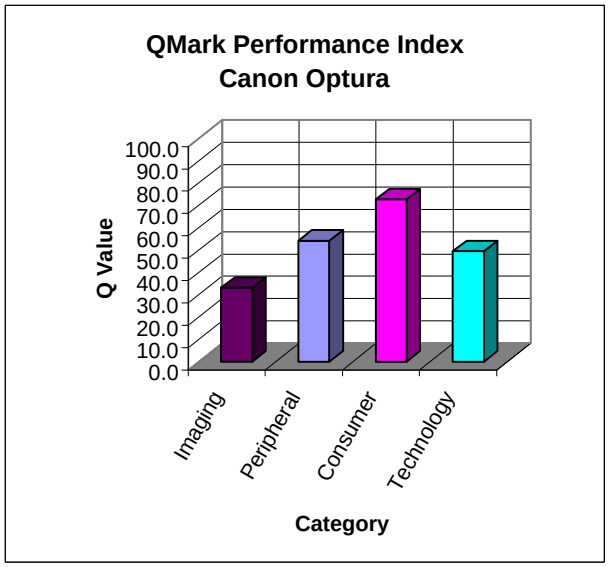

Figure 3: *The QMark metrics for the Canon Optura digital still-video camera*

Conclusions

The QMark camera quality measurement system is seen to be a compact, useful indicator of digital camera performance. Based on the work of standards organisations, the QMark method adds repeatable, subjective evaluations to complete a picture of camera quality. These subjective components of the QMark metric will evolve with time, with improvements in technology and understanding of the new medium of digital photography.

References

1. International Organization for Standardization, ISO/FDIS 12233, Electronic still-picture cameras - Resolution measurements, 1998

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3. International Organization for Standardization, ISO/FDIS 15739, Electronic Still Picture Cameras - Noise Measurements progress)

4. R.L.Kremens, QMark Evaluation Method, Questra Internal Document, 1998