NEW MODEL FOR EVALUATION OF THE PERCEIVED IMAGE QUALITY BY SMARTPHONE USERS

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Mobile devices, like smartphones and tablet computers, became an essential part in our life. Image quality assessment plays an important role in various image processing applications. A great deal of effort has been made in recent years to develop "objective" image quality metrics that correlate with perceived quality measurement. Unfortunately, only limited success has been achieved. In this paper, I provide a quantitative method to evaluate perceived image quality of color images on mobile displays. Five image quality factors - Vividness, Brightness, Clarity, Sharpness and Contrast were chosen to represent perceived image quality. Image quality assessment models are constructed based on results of human visual experiments compared with image analysis by SW tool.

Values of parameters of image quality assessment models are estimated based on results from human visual experiments, and a new model is proposed based on the human visual tests and computer image analysis.

Keywords: *Perceived IQ (Image Quality), Human Visual Experiments, MOS (Mean opinion score), subjective IQ.*

MODEL NOU DE EVALUARE A CALITĂȚII IMAGINII PERCEPUTE DE CĂTRE UTILIZATORII DE SMARTPHONE

Dispozitivele mobile (ca exemplu – smartphone și tablete) au devenit o parte esențială din viața noastră. Evaluarea calității imaginii joacă un rol important în diverse aplicații de procesare a imaginii. O mare parte din efort a fost făcut în ultimii ani pentru a dezvolta metrici „obiective" de evaluare a calității imaginii, care corelează cu măsurarea calității percepute. Spre regret, doar un succes limitat a fost atins în acest domeniu. În lucrare este prezentată o metodă cantitativă de evaluare a calității imaginii percepute cu referire la imaginile color pe ecranele dispozitivelor mobile. Cinci factori de calitate a imaginii – Intensitate, Luminozitate, Claritate, Rezoluție și Contrast – au fost aleși pentru a reprezenta calitatea imaginii percepute. Modelele de evaluare a calității imaginii sunt construite pe baza rezultatelor experimentelor vizuale umane în comparație cu analiza SW a imaginii.

Valorile parametrilor pentru modelele de evaluare a calității imaginii sunt estimate în baza rezultatelor experimentelor vizuale umane și un model nou este propus în baza testelor vizuale umane și de analiză a imaginii pe calculator.

Cuvinte-cheie: *IQ percepută (calitatea imaginii), experimente vizuale umane, MOS (scor mediu de apreciere), IQ subiectiv.*

1. Introduction

During the past decade we have witnessed a revolutionary growth in the use of Mobile Devices in digital imaging systems in our daily lives. These devices are now part of a broad range of applications, covering communication and entertainment. The resulting content is either stored on a memory device or is transmitted over the Internet (e.g. Facebook, YouTube).

The essential goal is to emulate or at least come close to human perception of image quality, using today's image processing technologies.

Why Bother About Better Image Quality?

Outside of the voice function, the camera is the most used feature in Smartphones.

Size of mobile displays is increasing for better Image Quality and ease of use. Number of pixels or PPI (pixels per inch) for mobile displays is also competitively increasing. Users are not necessarily utilizing their pictures.

The image content processed and displayed by these digital imaging systems largely differs in perceived quality depending on the system and its applications.

The displayed content is either captured by the embedded camera or from external source (e.g. other mobile device, Facebook, Instagram, YouTube etc.).

To be able to optimize the experience of Smartphone users of this content understanding and modeling perceived image quality is essential.

As a consequence, the model needs to quantitatively predict perceived quality of a degraded image without being able to compare it to its original image.

Although human beings judge image quality in a real-time without reference is a Subjective Image Quality assessment.

Developing a model to simulate this perception is still an industrial (by Mobile Devices vendors) and academic challenge.

Here we will not discuss how to increase the IQ of an image but what really matters to human perception and review a group of everyday natural images captured by most popular Smartphones used by people in all ages.

What factors make the picture more pleasing to the human eye? What really matters?

Camera phones currently on the market with identical image (Mega Pixel) resolution capabilities produce vastly different Image Quality.

Due to camera's sensor and display size limitations, increasing the number of megapixels in the Mobile Devices camera and the display size often leads to improve Image Quality.

Mobile Devices vendors do not have sufficient standardized metrics to compare one product to the next, they simply do side by side comparison of their product with others [1, 2].

At the same time, they know that Image Quality is important to consumers as an aspect of product quality, and important to motivate them to share those images.

As per now the Image Quality assessment for Smartphones carried out by Image Quality experts in the industry and some professional magazines and by the vendors [1].

The Image Quality is mostly "Subjective" and there is no official standard.

The IEEE (Institute of Electrical and Electronics Engineers) [3] organization has formed an international workgroup based on people from the Academia and Industry. The objective of that workgroup is to define the "CPIQ - Camera Phone Image Quality" standard (IEEE stds-p1858).

So What Really Matters?

Through a number of experiments and evaluations and research [4-6] it is apparent that the following five factors greatly influence the perception of good image quality:

1. **VIVIDNESS – color uniformity and richness**
2. **BRIGHTNESS – low light performance**
3. **CLARITY – no noise or distortion**
4. **SHARPNESS – great detail**
5. **CONTRAST – dynamic range**

2. The model
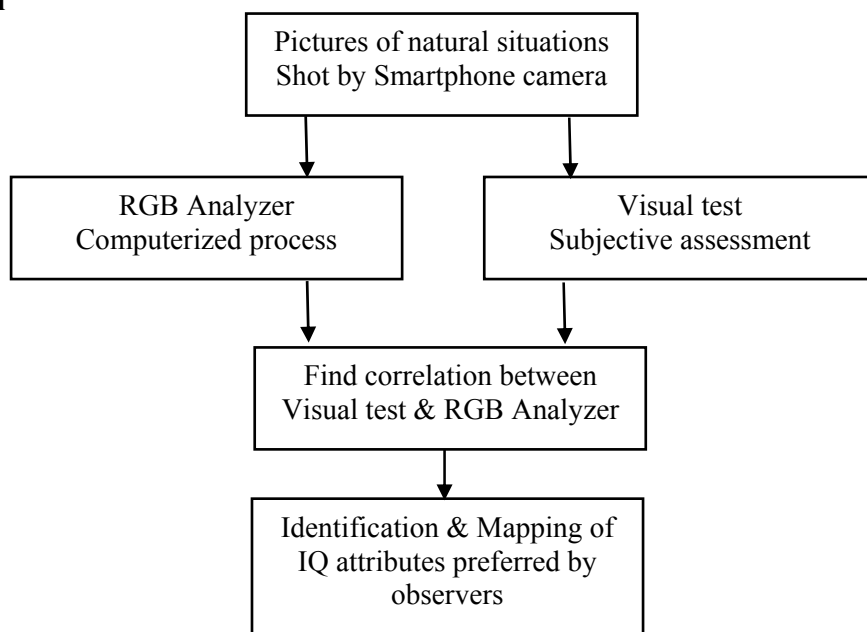
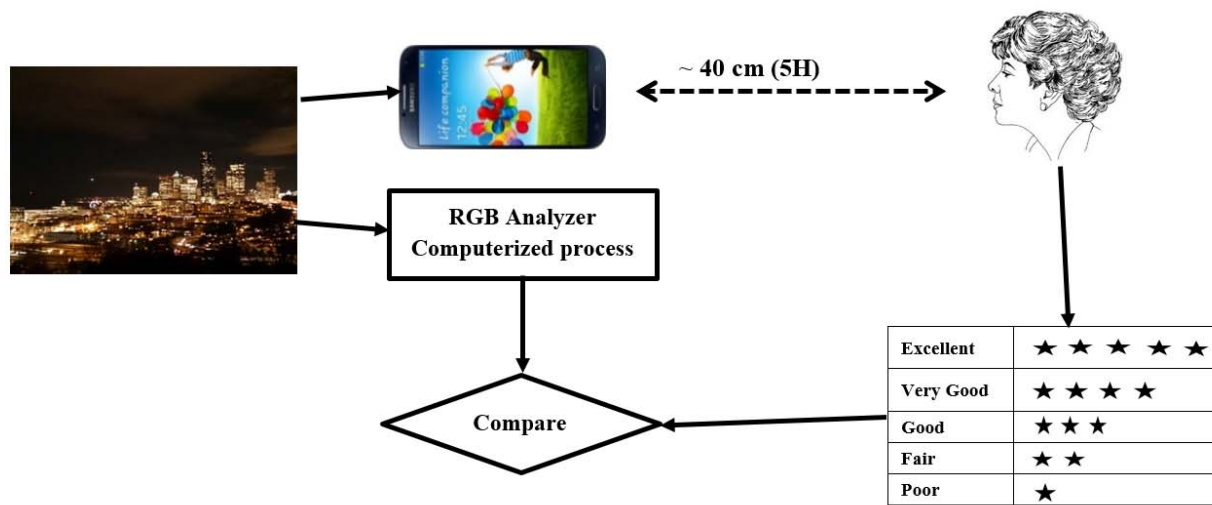**Fig.1.** New model of IQ visual tests and RGB analysis.

Fig.2. IQ visual tests and RGB analysis comparison.

The flow charts in Fig.1 and Fig.2 illustrate a new model for IQ human visual tests and computer RGB analysis of images, comparing results in order to find a correlation between the "Subjective" IQ assessment (by Human) and "Objective" analysis by SW tools. The outcome will help us recognizing what IQ attributes are preferred by Smartphones users.

Content

Pictures of 10 natural image contents [7]. Dimensions of pictures were 1920x1200.

Contents were carefully selected to represent a wide range of different situations and demands for pictures. Also, recommendations of Photospace standards set by I3A were considered when choosing the image contents.

4 different popular brands of smartphones camera used for pictures capture.

Altogether 40 different experiment pictures.

RGB Analysis

RGB Analyzer [1] measures the image pixel by pixel and performs graph with the distribution of image pixels in RGB color space with the luminance level.

In Figure 3 in below the image contains of 32 level of luminance of all basic colors.

The RGB Analysis graph demonstrates (Green dots) the population of image pixels in RGB color space, pixels cover all RGB basic colors and large color dynamic range.
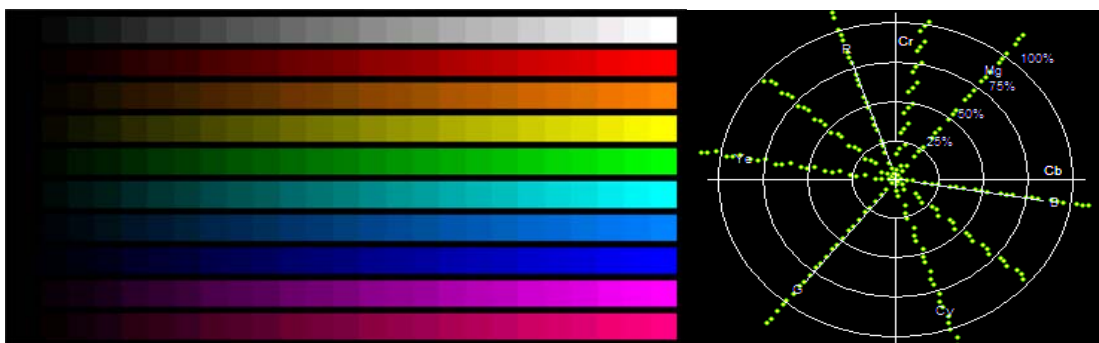

Fig.3. 32 levels Color bars and their RGB leves.

Figure 4 demonstrates the RGB Analysis of the content images with short data analysis of the IQ attributes. This will be used as an "Objective" scale while checking correlation between the "Objective" analysis and Human Visual Experiments results.

The content for the visual experiments was analyzed with SW tool in "RGB Analyzer" in order to get sort of "Objective" IQ attributes dominates in each image to be compared with the observers perceived IQ attributes.
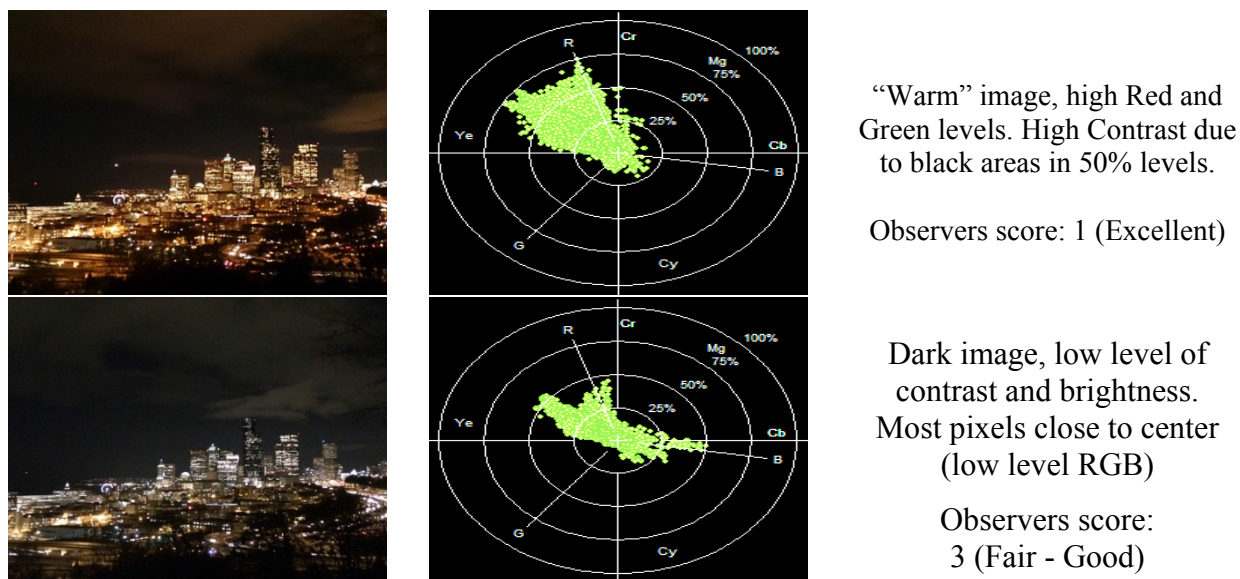
"Warm" image, high Red and Green levels. High Contrast due to black areas in 50% levels.

Observers score: 1 (Excellent)

Dark image, low level of contrast and brightness. Most pixels close to center (low level RGB)

Observers score: 3 (Fair - Good)

Fig.4. An example of RGB analysis and observers score comparison.

35 Observers
(In the industry the number of observers for visual test is about 10-12 due to time consuming and complexity of tests)
All observers have normal colour and short distance vision
Observers passed a short colour blindness and near distance vision experiment

Training
Observers did a quick training using the Samsung Galaxy S4 display as in the actual experiment.

Image Quality assessment
Observers watched 10 different scenes captured by 4 smartphones (total 40 pictures).
Observers had 1 minute for each scene IQ evaluation.
Observers must complete each scene IQ evaluation within 1 minute, they were
eligible to review the 4 images back and forth during the evaluation

Evaluations scales:
First observers evaluated the presented picture on the overall quality scale (MOS).
Next observers checked the best and worse presented picture with five different scales:
- Vividness – color uniformity and richness
- Brightness – low light performance
- Clarity – no noise or distortion
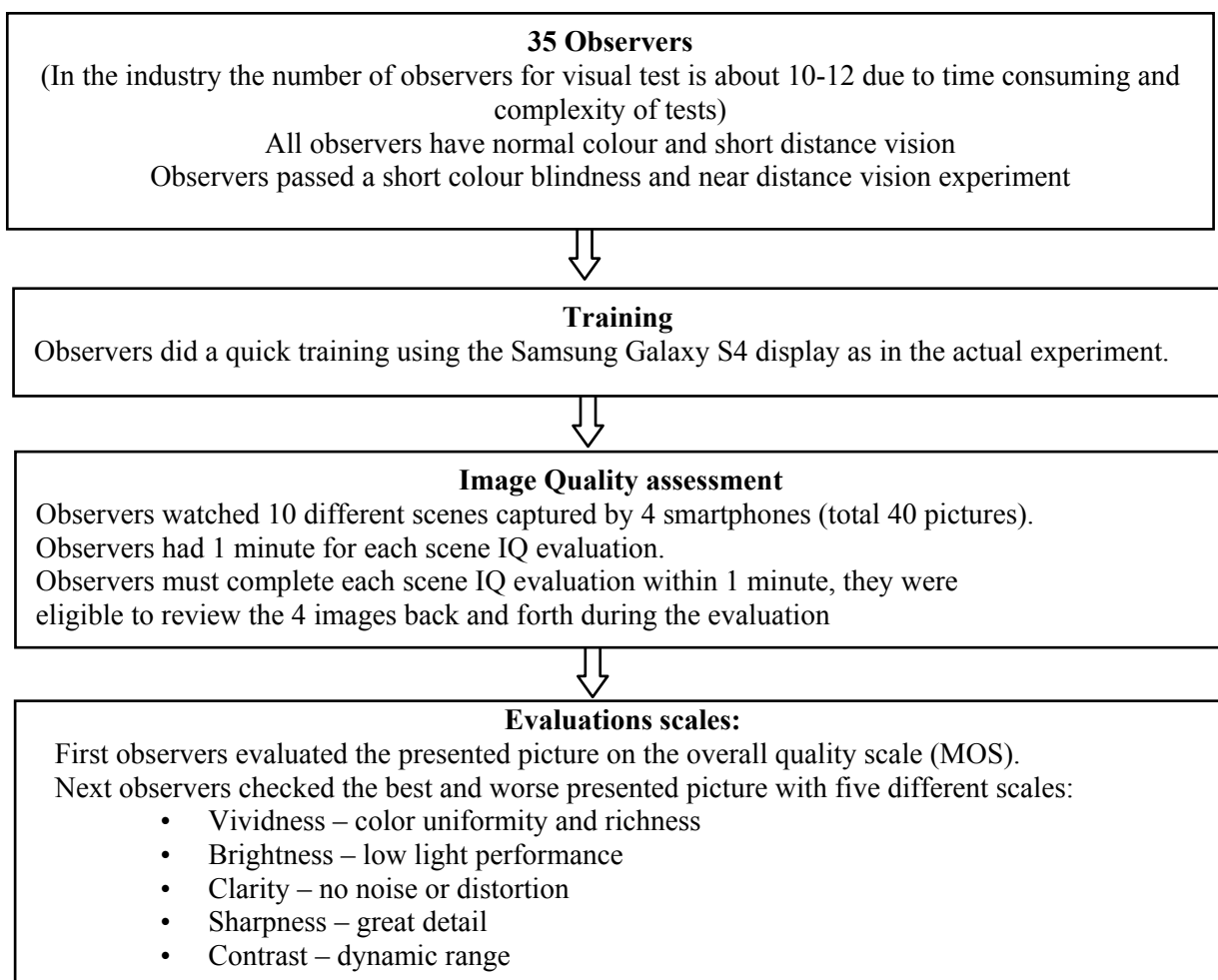- Sharpness – great detail
- Contrast – dynamic range

Fig.5. Human Visual Experiment flow chart [8,9]

3. Overall Image Quality results

The columns cahrts n Fig.6 show the total score in stars of each individual image received by the 35 observers in the visual experiment. Each chart present the 4 images of the same scene captured by 4 different mobile phone cameras with different IQ attributes. The scores were calculated from 35 response forme 1 (see Table 2 in attached file). In that visual experiment, observers were asked to score the images in "Overall Image Quality".
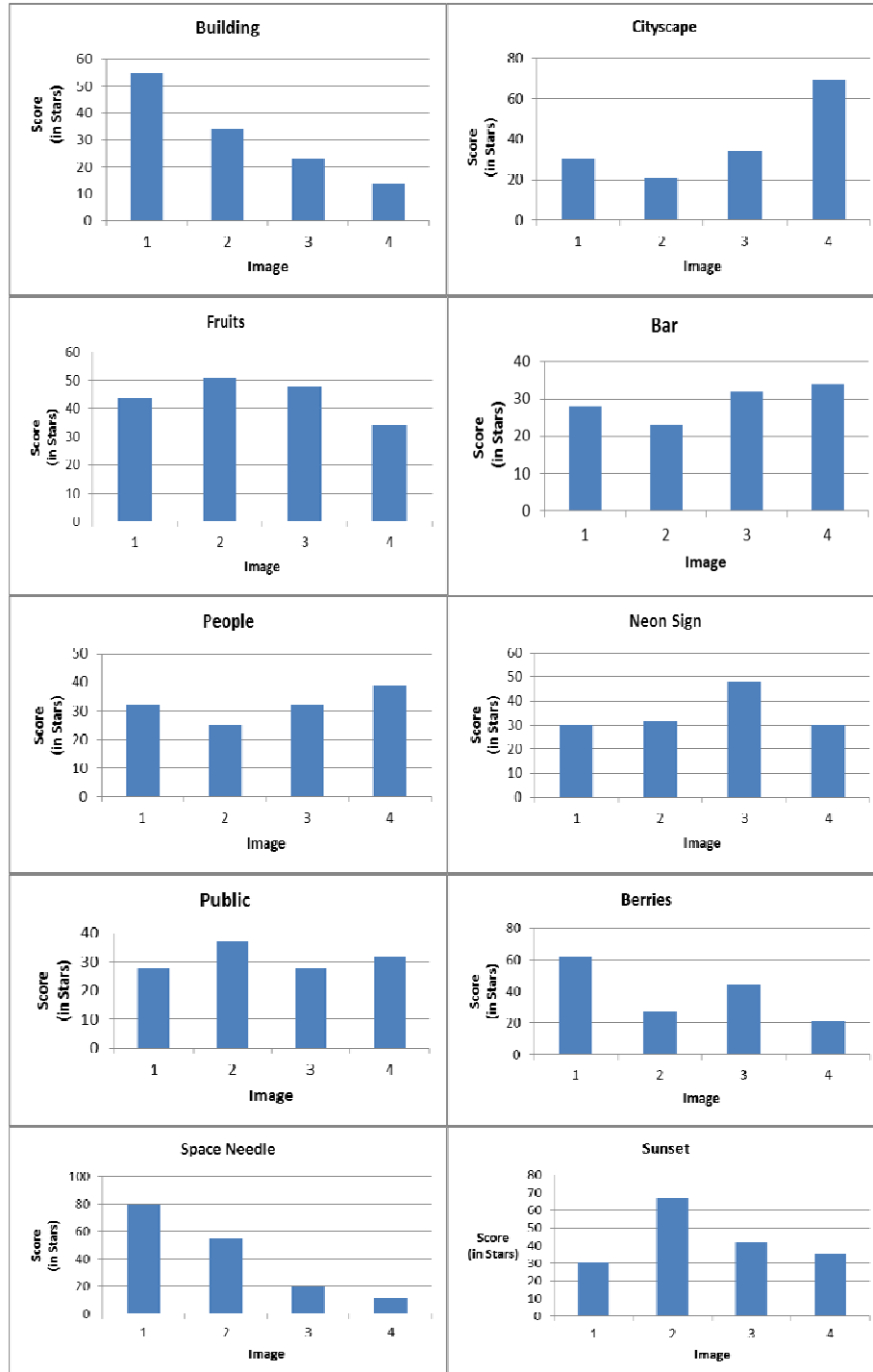
Fig.6. Columns charts of visual experiment.

Image Quality based on IQ factors

The charts in Fig.7 and Fig.8 present the number of observers (out of 35) that indicated on which IQ factors they based the scoring on the previous visual experiment (response form 1) of each 4 images cluster.

In response form 2 observers were asked to check (not scoring) which IQ factor contributes to their decision in previous visual experiment. IQ factors results are shown in Table 1.
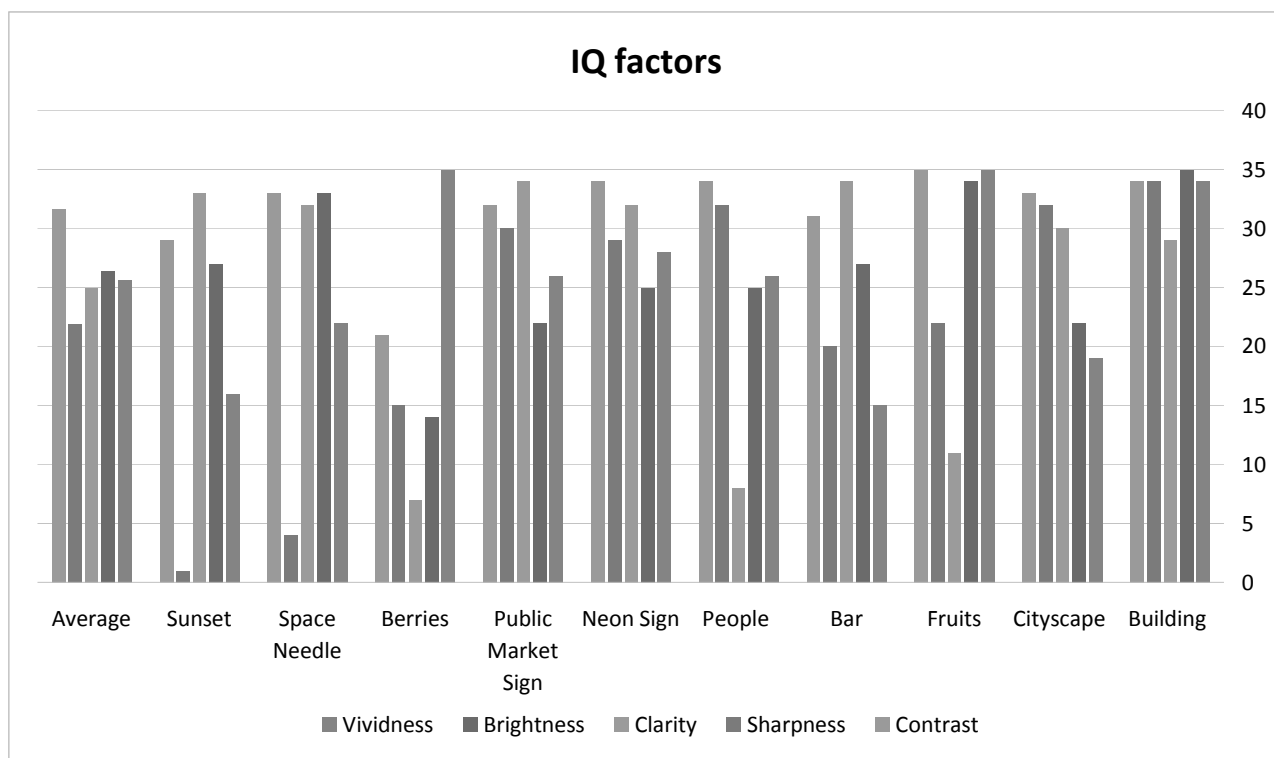

Fig.7. IQ factors results.

Table 1

IQ factors results

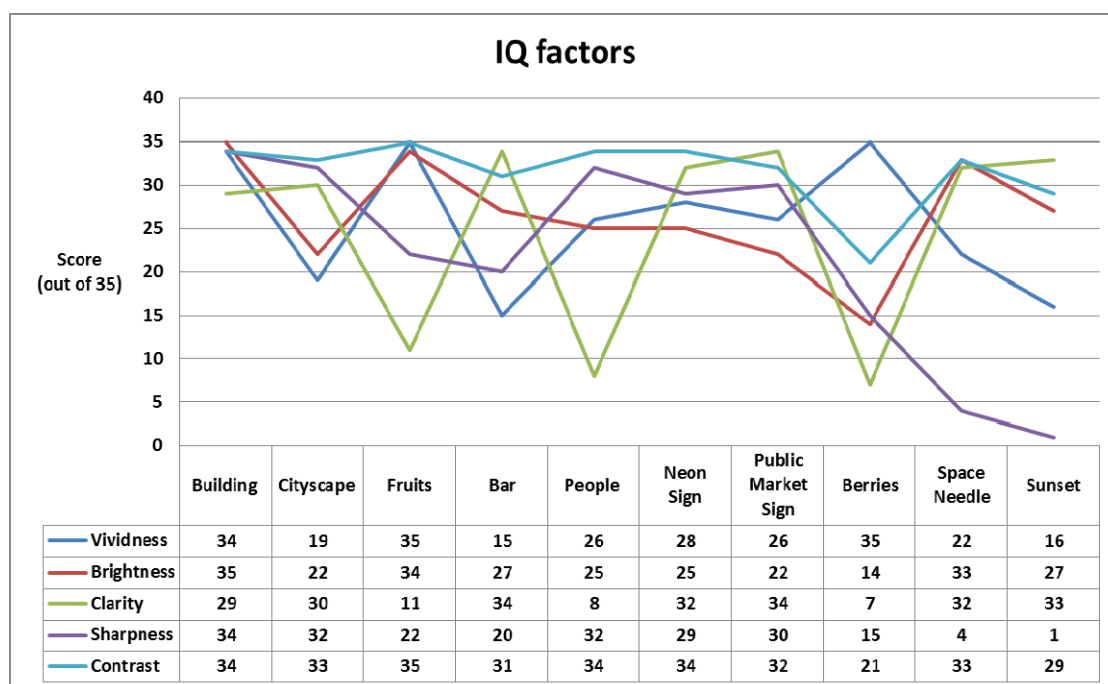| Image	Vividness	Brightness	Clarity	Sharpness	Contrast
Building	34	35	29	34	34
Cityscape	19	22	30	32	33
Fruits	35	34	11	22	35
Bar	15	27	34	20	31
People	26	25	8	32	34
Neon Sign	28	25	32	29	34
Public Market Sign	26	22	34	30	32
Berries	35	14	7	15	21
Space Needle	22	33	32	4	33
Sunset	16	27	33	1	29
Average	25.6	26.4	25	21.9	31.6

Fig.8. IQ factors results graphes.

4. Discussion

In phase 1 of Human experiments forty sample images used as experiment content. Ten clusters of ten different scenes, each cluster contents four images of same scene (e.g. Building) with different IQ attributes. Observers scored (in number of stars) each individual image compared to others in the same cluster. One question is asked to observers: **select the image with best Image Quality and give it score in stars (1-5 stars, excellent = 5 stars, poor = 1 star).**

Next in phase 2 observers were asked another question: **check the box of each noticeable IQ factor in each scene cluster.**

Subjective values of the visual experiments are calculated as JND (Just Noticeable Different) scales [3,8,9]. Values of JND in stars of overall perceived Image Quality and most significant IQ factors are obtained.

Figure 6 illustrates results from the 1st visual experiment ranks the IQ perception of observers of images in each cluster.

Numbers in Table 1 represent JND values of visual IQ factors and Figure 8 demonstrates the IQ factors domination in the images of the visual experiment.

5. Conclusions

The main goal of this study is to provide a reliable model based on human visual experiments on IQ assessment (calculating MOS) results compared with image analysis in RGB color space in order to find what IQ factors really matter for non-experts users, how the IQ perceived by users, these conclusions might help to predict how the next IQ technologies and features will be perceived by users.

Values of parameters of image quality assessment models are estimated based on results from human visual experiments [10-17].

While comparing the IQ scores and the content analysis in RGB, I found high correlation between the images that received highest scores by the observers and the analysis in RGB.

The most effective IQ factors are:

1. **VIVIDNESS** – color uniformity and richness
2. **BRIGHTNESS** – low light performance
3. **CLARITY** – no noise or distortion
4. **SHARPNESS** – great detail
5. **CONTRAST** – dynamic range

In this study, 2 deferent Human Visual experiments were designed to achieve credible outcomes while reducing time and resources needed for visual experiments. Observers scored images in quantitative scale, while the perceived IQ is "Subjective". Scores calculated and compared with "Objective" IQ (RGB Analysis). High correlation was found between the "Subjective" and the "Objective" assessment this helps in modeling of perceived IQ by "non-expert" observers.

Five image quality attributes, Vividness, Brightness, Clarity, Sharpness and Contrast are chosen to represent perceived Image Quality. Image quality assessment models are constructed based on results of human visual experiments.

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