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Non-bias Architectural Image Archive Using High Dynamic Range Approach

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Abstract—**The paper examines the imagery information and the qualitative characteristic of archiving non-bias architectural image using High Dynamic Range (HDR) imaging approach. Photography imaging became possible in the period of 19 century, it was a combination of several different scientific discoveries. Architectural photo imaging began with monochrome recording limitation, and the dynamic range recorded was inadequate even with analog color film. Often it was arguable if the photography image would provide reliable imagery information, either for aesthetic visualization purpose or to record accurate imagery information. The paper aims to analyze the limitations and issues that affect visual accuracy of HDR imaging digital workflow, including the environmental technical obstacles. Due to the situations of very contrast lighting condition, the extended dynamic range may be needed for archiving the real-world scene of architectural subject. The paper also explores the possibility of HDR imaging as an improved approach for non-bias architectural imaging archive.**

Keywords-high dynamic range; architectural image archive; non-bias scientific imaging study; multimedia

I. Introduction

Architectural image data can be used as part of the research content of urban morphology. Urban morphology research covers wide scope of study including to urban population, urban structural, urban transportation, ecology, mineralogy and forestry. Image is one of the core elements of Multimedia [16]. Non-bias architectural image archive involves identification and traceability [17] of original source of actual content is mandatory during the interpretation process of assessor. Beautified or manipulated imagery content may have to be considered as biased. Humans can represent the role of image interpreter [6] as a viewer or a creator. Therefore, biased imagery archives may potentially lead to high possibility of technical misunderstanding and interpretation error during the process of decision making.

The Leptis Magna coastal city of the Roman Empire is a UNESCO heritage site. During the 2011 Libyan civil war, NATO declined to comment whether or not it would strike the site if it knew that rebel's military equipment had been placed there [7]. Architectural structures from archeology site are extremely valuable for the urban morphology research. Preservation of archeology site is supported with the reliable imagery archives for future restoration work possibility and structural maintenance. To plan and arrange the restoration of a ruined archeology site may be nearly impossible if the subject is insufficient of accurate imagery archives of the architectural context at the original state. Image archives for postmodern and modern construction development serve many technical purposes for portraying, classifying and understanding the emerging landscapes [8]. Image archives are vital as evaluation reference for the construction site engineer and architect, that leads to further engineering considerations and design aspect for the project. The stake holders can evaluate the construction process remotely, by assessing the image archive references of the construction project.

A research funded by BBC where infrared images of NASA satellite taken by satellites orbiting 700 kilometers above the earth revealed the below-ground structures of Egyptian pyramids [13]. The expectation of imagery could be provided in near-real-time and major advantage of digital sensors is that the images can be visualized without the need of developing the analog film [10]. Imaging data being used as urban morphology research tool including the infrared imaging or the thermography [9] are approaches that aim to acquire extended technical imagery information, however optically work differently than the HDR imaging approach.

II. Background of High Dynamic Range (HDR)

High Dynamic Range (HDR) imaging in the digital workflow can be described as having similar image reproduction algorithm equivalent of dodging and burning process historically performed manually in a darkroom [20] of analog workflow using film. The HDR imaging digital workflow involves working with pre-calculation, multiple brackets of the image acquisition with digital camera instrument setup and specific post-processing for HDR image rendering. With HDR, the human viewing perception is allowed to view an extended range of visual luminance level in a locally adapted low dynamic range display. However the chromatic adaptation of viewing a HDR image [18], may cause viewer hard to differentiate the appearance of the HDR image comparing to the real-world scene. The experimental will observe and report possible limitations or issues of HDR imaging, including accuracy in visual results produced and arrangement of digital workflow handling process.

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III. Methodology of Experimental

A. Instrumental Setup

A Nikon manufactured D3X camera is used for this experimental preparation of HDR imaging digital workflow, for the acquisition of the RAW images for study, and the Nikon D3 series has been used by NASA ISS Crew Earth Observations experiment [11] and Image Science & Analysis Laboratory [12]. For this study, the archiving of HDR images is based on the combination of multiple bracketed exposures. The instrument of D3X is equipped with the Nikkor 18-35mm f/3.5-4.5D IF-ED Zoom lens. The D3X as a photo recording instrument can deliver 24.5 megapixels of image details, permits high magnification of inspection during the study. The auto-bracketing function of D3X allows continuous nine exposures to be made with one stop exposure increments at pre-user-defined aperture. This permits a HDR image archiving that covers a nine-stop exposure range to be acquired continuously.

Image acquisition was recorded in Nikon's RAW electronic format, as the RAW can be described as digital negative in the digital workflow [14], and all acquired RAW image files were being processed to 8-bit Jpeg using Capture One Pro 5, with linear curve to encourage all processed image files to be photometrically linear as possible [19]. This experimental setup understood that different raw processors may have different rendering intent resulting the processed images may have certain identical look comparing to other RAW processors. To reduce the possible bias of appearance resulted by the processed RAW image files, Gretagmacbeth color checker chart was used to have higher color consistency across the HDR imaging digital workflow during the experimental. Tone Mapping function of Photomatix Pro v4.0 [5] was used for the HDR image renderings. Sekonic J510 light meter was used to obtain the exposure reading and pre-calculation. The acquired image data may have certain level of exposure inconsistency, for example due to the rapid changes evening sky within the time needed to acquire the bracket of nine-stop exposure sequence.

To achieve a consistent digital workflow, a Monaco Optic XR Pro is used to calibrate the workflow across multiple viewing devices at D65 white point [2]. It is realistic and possible to perform colorimetric transformations on image data in attempts to match the colors across disparate devices and media, with the use of CIE colorimetry to specify images across [21] the various input-output devices. The nature of CIE colorimetry however restricted to situations in which the original and reproduction being viewed in identical conditions.

B. Measuring the Dynamic Range of Instrument Used

The D3X camera instrument was first being tested to quantify and verify the latitude of the projected dynamic range covered by the RAW image file of D3X at ISO100 setting. The measurement was tested in a lab environment, by photographing the Gretagmacbeth color checker chart with different brightness configuration of image sequence, as shown in Fig. 1 and Fig. 2.

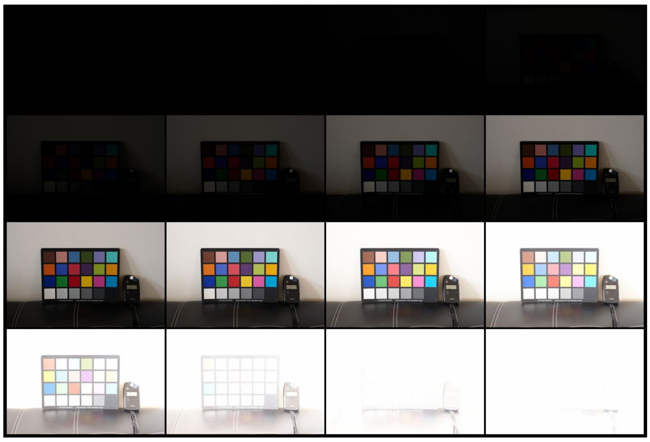

Figure 1. Image sequences of exposure graduation.

Figure 2. Inspection of exposure graduation from the sequence.

Fig. 3 illustrates the approximation of dynamic range of 8.5 exposure value (EV) with the instrument D3X, at ISO100. Neutral5 patch of the color checker was used to measure from darkest 0 to brightness 255 pixels level from the 16 photographed exposure sequences. It is assumable there are approximation of additional -2 and +2 exposure compensation headroom for dynamic range extension from each source of RAW image file. RAW from different instrument may have dissimilar overall RAW characteristic.

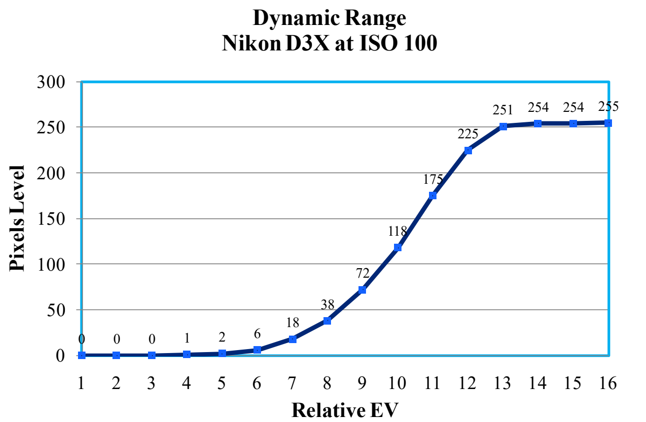

Figure 3. usable dynamic range approximation of 8.5 exposure value with D3X at ISO 100, RAW.

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IV. EXPERIMENTAL HDR IMAGE RENDERING

The experimental studies the visual perception of HDR imaging results by observing digital image directly processed from RAW, comparing to the two HDR imaging variations obtained from single source of RAW and multiple exposures. The architectural study subject is located at the lakeside of Taylor's University, Malaysia. The real-world scene situation has many difficult features to challenge the High Dynamic Range imaging workflow that includes under shade of the building, see-thru glassed indoor structure, reflective exterior glass, white wall, plant foliage, water, unpredictable or moving objects such as people and moving vehicles.

The experimental made samplings of same architectural study subject at two different lighting conditions labeled as the Lakeside Day Scene and Lakeside Night Scene. The experimental process was conducted from the similar photographic angle with instrument setup of D3X at ISO100.

Fig. 4 shows the comparisons of the visual archives from Lakeside Day Scene. Fig. 5 shows the comparisons of the visual archives from Lakeside Night Scene.

Fig. 4(a) and Fig. 5(a) were digital imageries produced directly from single exposure of RAW, the linear curve was checked during RAW processing without modifications nor adjustments. Fig. 4(b) and Fig. 5(b) were produced using one of the author's selection from the nine-stop exposure bracketed sequence, then being evaluated for extending the shadow and highlight recovery from RAW headroom, dynamic range of the selected single RAW were being further extended using RAW processor with compensation of -2, 0, +2 stop, later combined into a HDR image rendering. This reveals the extended content included the under shade building details and visible objects inside the see-thru glassed indoor structure. The Fig. 4(c) and Fig. 5(c) were local adaptation of HDR image renderings from the bracketed nine-stop exposure sequence of RAW.

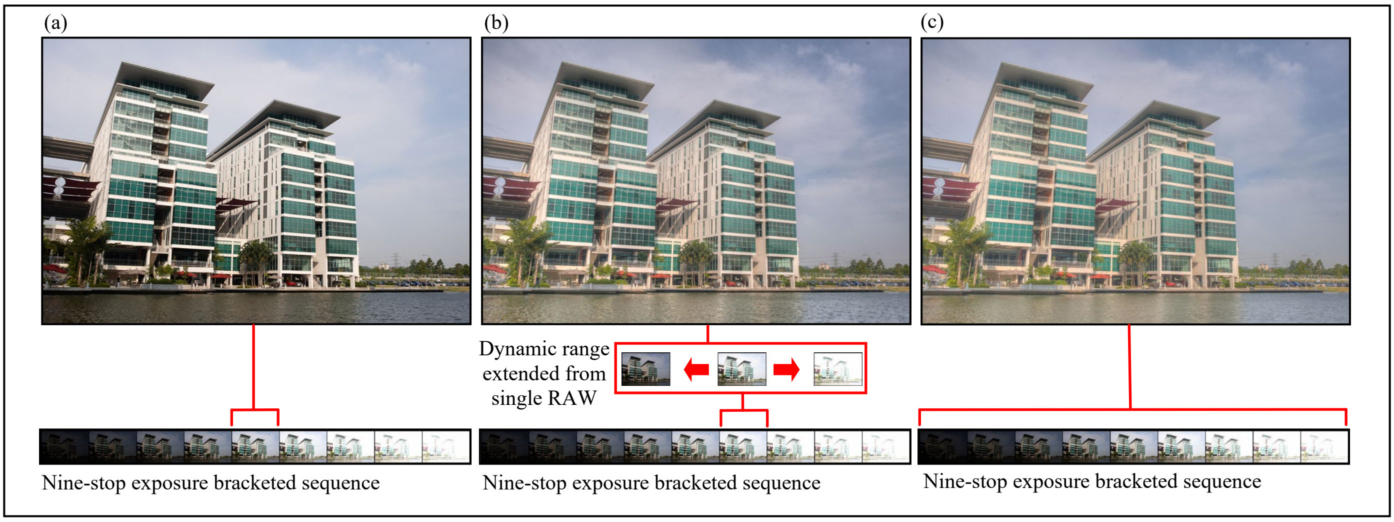

Figure 4. Lakeside Day Scene: (a) Single exposure of image rendering from RAW. (b) Local adaptation of HDR image renderings, from exposure value pre-extended from single source of RAW processing. (c) Local adaptation of HDR image renderings, from nine-stop of RAW exposure sequences.

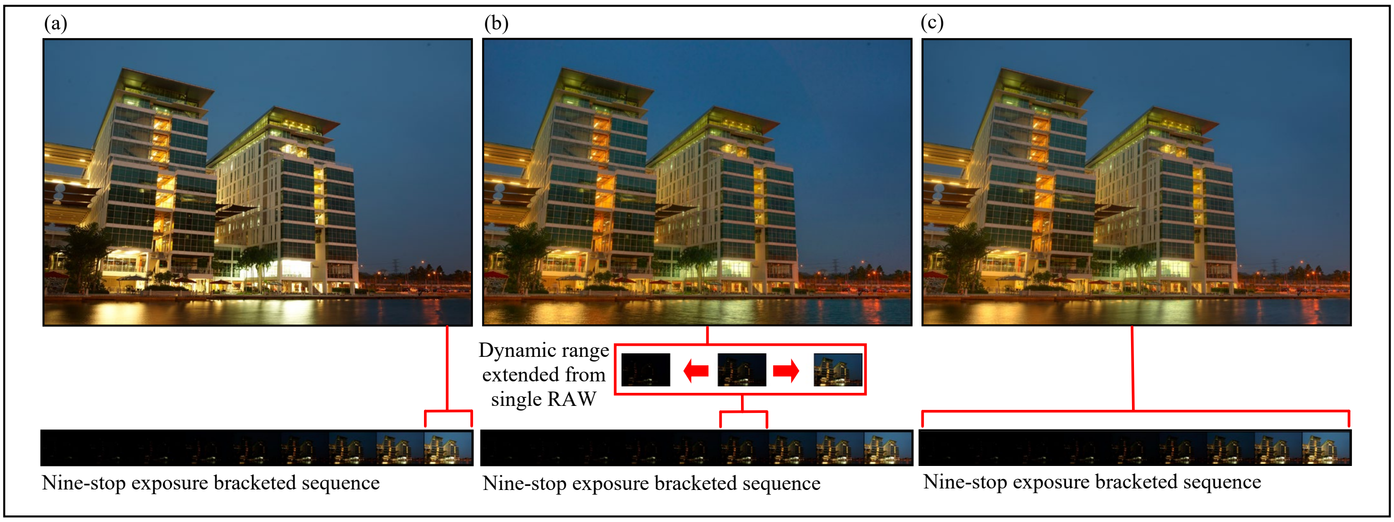

Figure 5. Lakeside Night Scene: (a) Single exposure of image rendering from RAW. (b) Local adaptation of HDR image renderings, from exposure value pre-extended from single source of RAW processing. (c) Local adaptation of HDR image renderings, from nine-stop of RAW exposure sequences.

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V. Observation of Study

The study observed several technical issues and limitations in the High Dynamic Range (HDR) imaging digital workflow. The observation carefully examined the imagery information produced quantitatively. A landscape analysis using digital imagery demands highly accurate geometric registration of image [15], including the depth of recorded dynamic range leads to a higher accurate interpretation of the assessor [2].

The observation examined the magnified comparisons of Lakeside Day Scene of Fig. 4(a), Fig. 4(b), Fig. 4(c) and Lakeside Night Scene of Fig. 5(a), Fig. 5(b), Fig. 5(c).

Fig. 6 shows that HDR image acquired from single source of RAW and HDR image acquired from multiple exposures of RAW exhibits greater imagery information at the shadow area compares to the low dynamic single image produced directly from RAW, however the HDR image acquired from single source of RAW exhibit the highest level of digital noise in image rendition.

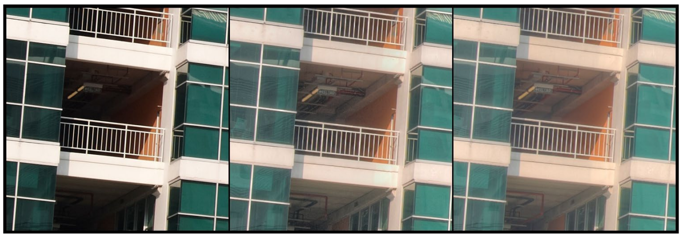

Figure 6. Magnified Lakeside Day Scene of Fig. 4(a), Fig. 4(b), Fig. 4(c) for observing the extended dynamic range comparison.

Fig. 7 shows that the HDR image acquired from multiple exposures displayed a "ghosting or damaged effect" from the moving objects presence in the scene, this includes the moving people and plant foliage. The movement of plants was due to the windy situation.

Figure 7. Magnified Lakeside Day Scene of Fig. 4(a), Fig. 4(b), Fig. 4(c) to observe the moving objects, including people, foliage, water.

The original dynamic range processed directly from the a RAW with linear curve produced approximately usable 8.5 exposure value (EV), this indicates that a tone mapping of HDR is needed in order to record visible imagery information beyond the capable range of instrument [4], in the situation where a given real-world scene contains lighting conditions more extreme than the contrast ratio of approximately 362:1. Fig. 8 further observed that the HDR image acquired from single source of RAW and HDR image acquired from multiple exposures of RAW, both produced greater shadow and highlight clipping imagery information compares to the low dynamic single image produced directly from RAW, as the HDR image acquired from single source of RAW exhibit the highest level of digital noise in image, especially in the darker image area of extended dynamic range being recovered during the RAW compensation of -2, 0, +2 stop.

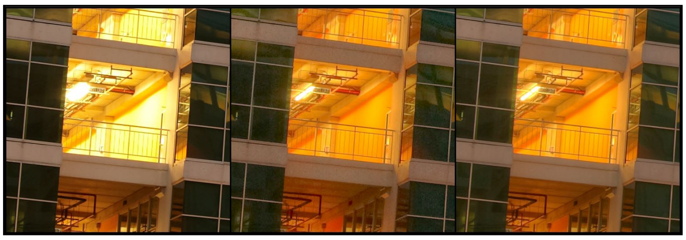

Figure 8. Magnified Lakeside Night Scene of Fig. 5(a), Fig. 5(b), Fig. 5(c) to observe the extended dynamic range and the noise apperearance.

The digital noise of the HDR image acquired from single source of RAW however does not degrade the appearance of the overall HDR image, in the example of Fig. 9. It is observed that this method can be the most stable way to avoid any presence of "ghosting or damaged effect", for the reason it was constructed from a single source of RAW file. Therefore all the moving objects including people, water, plant foliage will optically remain the way it was originally photographed from the source. All the HDR images produced in the experimental were being observed to have slightly higher saturation comparing to the normal photograph image processed directly from RAW.

Figure 9. Magnified Lakeside Night Scene of Fig. 5(a), Fig. 5(b), Fig. 5(c) to observe the extended dynamic range and the noise apperearance.

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The color value of the image pixels level may be exaggerated in the form of increased saturation during the HDR renderings. It was not intended to purposely saturate the HDR renderings, for example some colors may be saturated in the situation where a white wall that contains minor degree of yellow light fall onto it appears to be very yellowish in the local adaptation of HDR renderings.

The paper suggests that imagery information appears on an extremely reflective surface will be somehow difficult or unpractical to be recovered using the HDR imaging approach, this includes the reflective surface types such as metal materials, white wall, snow, water surface, glass or even a bright colored wall. Flare may be provoked from the reflective surfaces from the scene. In the case where flare is presence, particles in the air such as dust will disturb the data acquisition for HDR imaging digital workflow.

During the setup of HDR imaging digital workflow for the acquisition of exposure sequence bracket, the weather condition of the real-world scenario changes too quickly and may have resulted certain degree of inaccuracy in the acquired data in term of exposure value and the chromatic adaptation. The patterns of the potential inaccuracy are being illustrated in Fig. 10 and Fig. 11. The time and date of image data acquisition is presented in Table 1, this is to make a relation to the explanation of potential inaccuracy illustrated in Fig. 10 and Fig. 11.

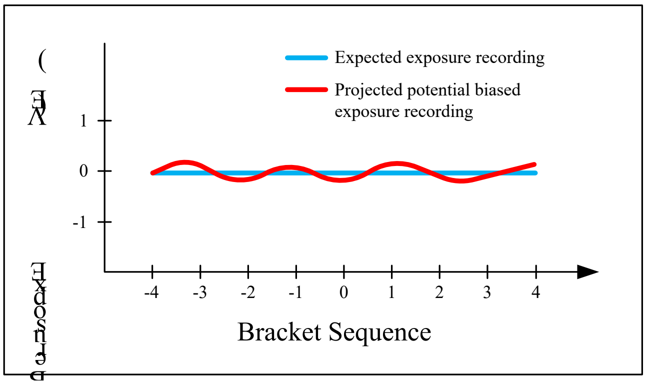

Figure 10. Pattern of potential inaccuracy for workflow during the day.

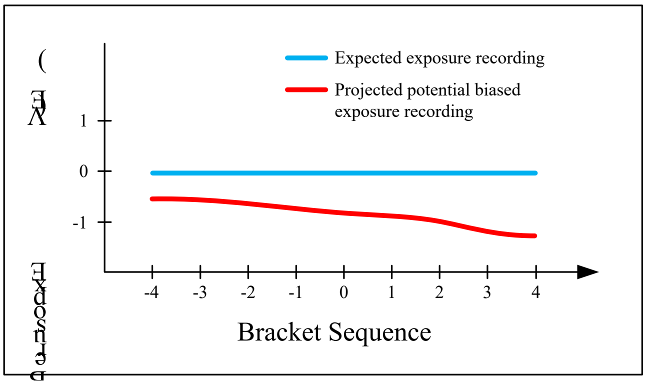

Figure 11. Pattern of potential inaccuracy for workflow during the night.

TABLE I. DATA ACQUISITION INFORMATION

Subject	Data
Name No. Exposure Exposure Stop Extended Date Time Start Exposure Time End Exposure Total Time Needed	Lakeside Day Scene 9 sequence -4 shadow, +4 hightlight 28 June 2011 17:30:28pm 17:30:37pm 9 seconds (approximation)
Name No. Exposure Exposure Stop Extended Date Time Start Exposure Time End Exposure Total Time Needed	Lakeside Night Scene 9 sequence -4 shadow, +4 hightlight 28 June 2011 19:44:05pm 19:44:31pm 26 secords (approximation)

Table 1 described the potential occurrence of inaccuracy image data during the period of content acquisition. For the Lakeside Day Scene, the total time needed of 9 seconds permits the possibility of clouds covering the sunlight or vice versa, therefore resulting the luminance level of the real-world scene increased or decreased unpredictably. The situation is not the same for the Lakeside Night Scene, the nine-stop exposure bracketed sequence were acquired during the evening when sun set at the west resulting the set of acquired image data having gradual decreasing of exposure value (EV) within the 26 seconded needed. Visual appearance for local adaptation renderings of HDR suggests future research possibilities to study the appearance accuracy and perception. Such continuous research innovation includes the implementation of iCAM for tone mapping of HDR images [3] and iCAM06: a refined image appearance model for HDR image rendering [1]

VI. CONCLUSION AND IMPLICATIONS

The paper suggests that HDR imaging can be minimal-bias towards a non-bias approach for architectural image archive. The obstacles such as issues being observed including "ghosting or damaged effect" of moving objects are considered elements not related to architectural context. Architectural context including the building structural was recorded with sufficient visible imagery information in the shadow and highlight areas of the HDR images, meanwhile optically geometrical registration original to the instrument setup.

The HDR image acquired from multiple exposures of RAW exhibits several visual issues and limitations, however it covers the greatest dynamic range from the exposure bracketed sequence of the real-world scene. The experiment finds that the HDR image renderings acquired from single source of RAW is technically considered more effective due the least visual issues and limitations being observed. This method does not require the camera instrument to acquire more than one usable source of exposure, and it leads to an optimal recorded visual accuracy possible towards an improved approach specifically for architectural context image archive.

ACKNOWLEDGMENT

The authors would like to thank every counterpart who contributed to the study.

REFERENCES

[1] Kuang, J., G.M. Johnson, and M.D. Fairchild, "iCAM06: A refined image appearance model for HDR image rendering," Journal of Visual Communication and Image Representation, 2007. 18(5): pp. 406-414.

[2] M.D. Fairchild, "The HDR Photographic Survey", RIT, Munsell Color Science Laboratory, Rochester, New York (2007)

[3] M.D. Fairchild and G.M. Johnson, "The iCAM framework for image appearance, image differences, and image quality," Journal of Electronic Imaging, in press (2004).

[4] G.M. Johnson and M.D. Fairchild, "Rendering HDR images," IS&T/SID 11th Color Imaging Conference, Scottsdale, pp.36-41 (2003).

[5] S. Uwe, G. Juergen, "The Digital Photography Workflow Handbook," 2010.

[6] Shih, N.-J. and Y.-T. Tsai, A photogrammetry-based verification of assumptions applied in the interpretation of paper architecture. Computers & Graphics, 2002. 26(1): pp. 109-124.

[7] T. Ishaan, "With Roman Ruins Under Threat, Libya's Ancient Past Presses Against Its Present," http://globalspin.blogs.time.com/2011/06/14/with-roman-ruins-under-threat-libyas-anci (accessed Jun. 2011)

[8] Gospodini, A., "Portraying, classifying and understanding the emerging landscapes in the post-industrial city," Cities, 2006. 23(5): pp. 311-330.

[9] Plaza, A., et al., "Recent advances in techniques for hyperspectral image processing," Remote Sensing of Environment, 2009. 113(Supplement 1): pp. S110-S122.

[10] Norris, P., "Developments in high resolution imaging satellites for the military," Space Policy, 2011. 27(1): pp. 44-47.

[11] NASA, "The Gateway to Astronaut Photography of Earth," Image Science and Analysis Laboratory, NASA-Johnson Space Center, http://eol.jsc.nasa.gov/sseop/metadata/Cameras/D3.htm (accessed Jun. 2011)

[12] NASA, "Open Pit Mines, Southern Arizona," http://earthobservatory.nasa.gov/IOTD/view.php?id=42555 (accessed Jun. 2011)

[13] Discovery, "Egyptian Pyramids Found With NASA Satellite," http://news.discovery.com/archaeology/pyramids-egypt-nasa-satellite-110526.html (accessed Jun. 2011)

[14] Adobe, "Digital Negative (DNG)," http://www.adobe.com/products/dng/ (accessed Jun. 2011)

[15] T.M. Lillesand, and R. W. Kiefer, "Remote sensing and image interpretation". United States of America: John Wiley & Sons Inc. (2000).

[16] S. McGloughlin, "Multimedia Concepts. Multimedia Concepts and Practice," pp.1-41. United States of America: Prentice Hall (2001).

[17] Brouse. and S.L. Peggy, "A process for use of multimedia information in requirements identification and traceability". Ph.D. dissertation, George Mason University, United States of America, 1992.

[18] K. Hirakawa and T.W. Parks, " Chromatic adaptation and white-balance problem". in Image Processing, 2005. ICIP 2005. IEEE International Conference (2005).

[19] M.K. Johnson, "Capturing Linear Images," http://www.mit.edu/~kimo/blog/linear.html (accessed Jun. 2011)

[20] M.D. Fairchild and G.M. Johnson, "Meet iCAM: An Image Color Appearance Model," IS&T/SID 10th Color Imaging Conference, Scottsdale, (2002).

[21] M.D. Fairchild and G.M. Johnson, "Image appearance modeling," SPIE/IS&T Electronic Imaging Conference, SPIE Vol. 5007, Santa Clara, 149-160 (2003).