DEVELOPMENT OF VIDEO FRAME ENHANCEMENT TECHNIQUE USING PIXEL INTENSITY ANALYSIS

H. A. Abdulkareem, A. M. S. Tekanyi, I. Yau and B. O. Sadiq
ABU FM Radio & BBC Studio, Ahmadu Bello University, Zaria, Nigeria

ABSTRACT: This paper developed a brightness enhancement technique for video frame pixel intensity improvement. Frames extracted from the six sample video data used in this work were stored in the form of images in a buffer. Noise was added to the extracted image frames to vary the intensity of their pixels so that the pixel values of the noisy images differ from their true values in order to determine the efficiency of the developed technique. Simulation results showed that, the developed technique was efficient with an improved pixel intensity and histogram distribution. The Peak to Signal Noise Ratio evaluation showed that the efficiency of the developed technique for both grayscale and coloured video frames were improved by PSNR of 12.45%, 16.32%, 27.57% and 19.83% over the grey level colour (black and white) for the NAELS1.avi, NAELS2.avi, NTA1.avi and NTA2.avi respectively. Also, a percentage improvement of 28.93% and 31.68% were obtained for the coloured image over the grey level image for Akiyo.avi and Forman.avi benchmark video frame, respectively.

Key Words: Video frames, Enhancement filter, Pixel intensity, Histogram distribution, Pre-processing, PSNR

1. INTRODUCTION
Digital images can be considered as a large array of discrete dots, each of which has a brightness associated with it. These dots are called picture elements or simply pixels (Pandey et al., 2015). Pixels are the smallest discrete component of an image. These pixels are often corrupted with noises which are inherent in the image. Therefore, before further processing of an image or video data, it is necessary to remove noise (Boon and Guleryuz, 2006), (Siddavatam et al., 2011), (Roopashree et al., 2012). Image pre-processing is the term used for operations on images at the lowest level of abstraction. These operations do not increase image information content but they decrease its entropy information measure (Fan and Jin, 2010), (Kamboj and Rani, 2013), (Garg and Kumar, 2012). Neighbouring pixels corresponding to one real object have the same or similar brightness value (Li et al., 2010). If a distorted pixel can be picked out from the image, it can be restored as an average value of neighbouring pixels (Li et al., 2011). Image pre-processing methods can be classified into categories according to the size of the pixel neighbourhood that is used for the calculation of new pixel brightness (Padanathi et al., 2012). Brochier et al., 2015). In literatures, images are broadly classified into two types which are the grey scale image and the coloured images (Verima and Ali, 2015). The grey scale images are typically 2D images and the coloured images are the 3D images. The primary reason for pre-processing these types of images is to remove noise (Ballabeni et al., 2015). A number of researchers have explored new and improved ways of enhancing and restoring video quality such as the works of (Zhang et al., 2013), (Ghailke and Ganorker, 2013). The authors in (Zhang et al., 2013) developed a fast-recursive algorithm to estimate the decoder-side distortion of each frame in the presence of packet loss. The algorithm operated at block level and considered the impacts of different intra prediction modes. An optimization problem was formulated to minimize the decoder-side distortion by allocating a given channel coding redundancy among a group of frames. Various techniques were introduced to speed up the algorithm without sacrificing too much accuracy in order to meet the hardware and real-time constraints of the system. As a result, the developed scheme could run on a real-time embedded video conferencing system with resolution of up to 1024×576 pixels, 30 frames per second (fps) and 4 megabits per second (Mbps). Luminosity conserving and contrast enhancing histogram equalization method for color images was developed by (Gwangil, 2014). All RGB images were transformed into different color spaces and particular channels were applied to the histogram equalization process. The final result showed that HSV color space yielded favourable results in MSE by giving good luminosity conserving ability. It is always established that HSV color space is characterized with a lot of drawback, some of which are
freezing of color as a result of oscillation created by chips in the camera whose end result is noise. (Vishwakarma and Mishra, 2012), (Ghadke and Ganorker, 2013) critically reviewed the color image enhancement techniques. Their research work revealed that histogram equalization cannot preserve the brightness and color of the original image. In view of these, this paper aims to develop a brightness enhancement technique for video frame pixel improvement based on pixel intensity analysis to improve the quality of the video frame.

2. METHODOLOGY
The step by step procedure adopted in this research to develop, a novel image brightness enhancement technique based on image quality is highlighted as follows:

2.1 Acquisition of video data on which the developed technique was implemented.
2.2 Elimination of hue and saturation whilst retaining luminance intensity of images.
2.3 Noising and filtering of images.
2.4 Development of the achieved brightness enhancement technique

2.1 Video Acquisition
A total of four acquired video data and two benchmark video data were used in order to efficiently determine the performance of the developed technique under different conditions. The sample of these video frames is presented in Figure 1.

From Figure1, the first two sample videos from NAERLS (NAERLS1.avi and NAERLS2.avi) were obtained using the video camera system of NAERLS. Similarly, the two sample videos from
NTA (NTA1.avi and NTA2.avi) were obtained using the video camera system of NTA, Abuja Broadcasting Station and the last two benchmark videos (Akiyo.avi and Forman.avi) were also obtained from the standard image database (VintaSoftImaging.Net). MATLAB R2015a image processing toolbox was used on individual video images obtained and represented in Figure 1 to achieve the information on each video as shown in Table 1.

| SN | File Names      | File Size (*.avi) | Number of file Frames |
|----|-----------------|-------------------|-----------------------|
| 1  | NAERLS1.avi     | 18.1Mb            | 157                   |
| 2  | NAERLS2.avi     | 10.3Mb            | 155                   |
| 3  | NTA1.avi        | 9.6Mb             | 152                   |
| 4  | NTA2.avi        | 11.2Mb            | 200                   |
| 5  | Akiyo.avi       | 11Mb              | 300                   |
| 6  | Foreman.avi     | 7.25Mb            | 100                   |

It is noteworthy that, videos are frames of dynamically changing images and images are usually derived from video cameras in the form video frames. Therefore, the video data given in Table 1 were initially converted into frame of static images and cropped for easy processing and analysis.

2.2 Eliminate Hue and Saturation and Retain Luminance Intensity

The next stage in the pre-processing was to extract the luminance information from the true colour image by removing the hue and saturation. In order to achieve this, conversion formula was employed as follows (Keith, 2005):

\[
\text{Intensity} = a \times \text{red} + b \times \text{green} + c \times \text{blue}
\] (1)

where a, b, and c are the hue weighted average of the images Red, Green, and Blue (RGB) channels. Note; the fundamental basic luminance (brightness) equation is given as

\[
Y = 0.299R + 0.587G + 0.114B
\]

and the sum of the three coefficients of red, green and blue is 1 (Keith, 2005). These individual values of channels are usually greater than zero, depending on the colour content of the original image. These coefficients were adjusted based on sensitivity to colours until appropriate luminance intensity was obtained. The constituent colours of the image were extracted and the image intensity given in equation (1) was transformed into equation (2): (Keith, 2005)

\[
\text{Intensity} = a \times (1,:) + b \times (2,:) + c \times (3,:)
\] (2)

From equation (2), the first matrix is with only the coefficient multiplying the Red, coefficient of both Blue and Green represented in hidden does not exist. The same procedure as in the second and third matrix where the Blue and Green exist.

2.3 Noising and Filtering

Noise was applied to the intensity image given in equation (2). Four different types of noise (Gaussian, Poisson, salt&pepper, and speckle) were implemented. The essence of this introduction of noise was to randomly vary the intensity of the image such that the pixel values show different values from its true values. By so doing, the actual image was separated from its background. Since the image intensity ranges from 0 to 1, an addition of parameter \(d\) was used to control the level of the noise added to the image. This was implemented using the inbuilt image processing toolbox in MATLAB R2015a and its snippet is given as follows:

\[
\text{IM}=\text{IMAGE};
\]

\[
\text{IN1}=\text{imnoise} (\text{IM},'\text{salt & pepper}',d);
\]

\[
\text{IN2}=\text{imnoise} (\text{IM},'\text{poison}',d);
\]

\[
\text{IN3}=\text{imnoise} (\text{IM},'\text{gaussian}',d);
\]

\[
\text{IN4}=\text{imnoise} (\text{IM},'\text{speckle}',d);
\]

The Noisy Image (\text{IN}) from this operation was smoothed using the median filter and hybrid median filter which are two of the most widely used filtering technique. The median filtering was done by selecting the median value from the neighborhood as the output of each pixel (Sadiq and Sani, 2015). The inbuilt image processing
toolbox in MATLAB R2015a was used for its implementation as follows:

\[
\text{IMF1} = \text{medfilt2}(\text{IN}, [K, L]);
\]

\[
\text{IMF2} = \text{hmf}(\text{IN}, [K, L]);
\]

where, \( K \) and \( L \) are the selected neighborhood operation of the image and \( \text{IN} \) is the noisy image obtained from the previous operation.

### 2.4 Development of the achieved Brightness Enhancement Technique

This research work used a different enhancement technique based on the following approach:

i.) At the first stage, the pixel values throughout the image was extracted and stored in a buffer \( (B) \). The dimensional sizes of the image were first determined and stored as \( X \) number of rows and \( Y \) number of columns. Therefore, from MATLAB toolbox R2015a, each pixel value extraction formula is given as:

\[
B(k + 1) = \sum_{k=0}^{N} \left( \frac{I(k)}{X \times Y} \right)
\]  

where:

\( N \) is the total number of possible intensity levels, which are usually 256 for 8-bit grey scale image. \( I \) is the input image, note; the product of the row and column, \( X \) and \( Y \) is the area of the frame. Also consider the buffer \( B \) \((k + 1)\) as an empty box where each frame is sampled into, and that sampling of the frame starts from \( k = 0 \) to \( k = N \) as can be seen from the flowchart in Figure 2. The bar is an indication of the whole columns of the matrix representing the frames sampled into an empty box.

Equation (3) only extracts part of the image that constitute the pixel information

ii.) At the next stage, the pixel information from equation (3) is converted into a pixel matrix as follows using MATLAB code:

\[
W = \sigma \times [1, (N + 1)]
\]  

Therefore, substituting equation (4) into equation (3) gives the following:

where \( \sigma \) is a variable coefficient (variable, so starts from zero) and \( B(l + 1) \) is the updated picture information.

\[
B(l + 1) = \sum_{m=0}^{N+1} B(m) + \sum_{l=0}^{N+1} w(l)
\]  

\[ B(m) \] is the pixel and \( w(l) \) is the matrix defining each pixel.

iii.) In this stage, the elements of the update equation (5) were converted to integer values for further processing as follows:

\[
R = \left\lfloor B(l + N) \times (N + 1) + 0.5 \right\rfloor
\]

The addition of 0.5 in equation (6) was to ensure that the element of the image stored as \( R \) was always rounded up to 1 because this is when the maximum intensity of the image is achieved. The probability density function of brightness is always rounded to 1 (Ian et al., 1995).
Import the Video Data

Start

Determine the Total Number of Frames?

Determine the Pixel Intensity \(? N\)?

\(K \leq N\)

Yes

\(l \leq N + 1\)

Update Pixel Intensity

No

Yes

Extract the Pixel Content

\(i \leq N\)

\(j \leq N\)

Update Pixel and Output Result

No

Yes

Apply Histogram Distribution

Figure 2: Flowchart Implementation of Luminance Enhancement Technique
The values of equation (3) that correspond to any of the values of R were determined and stored as P using the following:

$$P = \sum_{i}^N \text{sum}(B(\text{find}(R = i)))$$  \hspace{1cm} (7)

where sum and find are operators in the MATLAB code. Equation (7) is the improved brightness or luminance of the employed method that enhanced the level of luminance intensity.

In the final stage, the pixel values of the original image were compared with R and the best from both images was kept. This was achieved using the following formula:

$$F(\text{find}(I = i)) = \sum_{i=0}^N R(i + 1)$$  \hspace{1cm} (8)

Note; the use of find is very necessary in equation (8), was to determine the linear indices corresponding to the nonzero element of the image.

The output from equation (8) was the improved brightness or luminance of the used image brightness enhancement technique. This technique is robust to any kind of image whether coloured or grey scale images these were evident in the result of the enhancement model.

3. RESULTS AND DISCUSSION

The acquired video samples were read and converted into image frames, which were resized to (176x144) which is equivalent to 43.3kB. Hue and saturation were eliminated to give images shown in Figure 3.

In order to determine the efficiency of the luminance enhancement technique, the pixel values of the hue and saturation free image in Figure 3 were randomly varied by the introduction of noise (see its snippet in section 2.3), then filtered to smoothen the output. The filtered image
was passed through the luminance enhancement technique and the result is shown Figure 4.

Figure 4: Luminance Intensity of Black and White Video Frames after Enhancement

The impact of the technique (luminance enhancement) used clearly shows that, each frame in Figure 4, appears to be brighter, sharper and rich in contrast when compared with their equivalent frames in Figure 3. In order to provide a clear justification for this statement, the histogram of each of the sampled video frames and the benchmark video frames were generated from the MATLAB stimulation environment as shown in Figure 5. This is the vectors representation of the image pixels at different intensities using histogram distribution.
Figure 5 (a & b) show histogram representation of the NAERLS1 and NAERLS2 sampled image before the application of the luminance enhancement technique while Figure 5 (b & d) show the histogram of the frames after enhancement. It should be observed that, the luminous intensity of the NAERLS1 frame (Figure 5 a) has been significantly improved and distributed across the pixel values in Figure 5 (b). Similarly, the luminous intensity of NAERLS2 sample frame given in Figure 5(c) is improved significantly across the pixel values of the frame in Figure 5(d). Note this is the improvement of the source original image in terms of the PSNR.
Figure 6 (e) and Figure 6 (f) show the respective histograms of the NTA1 sample video frames before and after luminance enhancement. Also, Figure 6 (g) and Figure 6 (h) show the histogram of the NTA2 sample video frame before and after the luminance enhancement. It is observed from both Figure 6 (f) and Figure 6 (h) that the histograms of the frames from both cases have an improved luminous intensity with a much better distribution across the pixel values of each frame. This is an indication of how much of enhancement is done on the frames.
Figure 7(i) and Figure 7(j) show the respective histograms of the Foreman.avi benchmark video frames before and after luminance enhancement, while Figure 7(k) and Figure 7(l) show the histograms of the Akiyo.avi benchmark video frame. In both figures, it is observed that the intensity of the frames has improved throughout the pixels values with a much better distribution. This also, is an indication of how much enhancement is done on the benchmark frames. In order to evaluate the robustness of the luminance enhancement techniques presented in this report, the technique is applied to the coloured frame of all the six sampled videos. This is to determine how much of improvement can be done on the frames containing hue, saturation and luminance all together using the brightness (luminance) enhancement technique.

The enhancement technique was also applied to the coloured sampled frame of the two benchmark videos. The original and enhanced frames of Akiyo benchmark video, with their corresponding histograms are given in Figure 8.
Figure 8: Coloured Images and Histograms of Original and Improved sample of Akiyo

From Figure 8, it is observed that the histogram of the original Akiyo.avi benchmark sample video frame of Figure 8(a) shows a much better improvement in Figure 8(b) after the application of the enhancement technique. Table 2 is the black and white (grey level) performance evaluation using Peak Signal-to-Noise Ratio.

### 3.1 Performance Evaluation using Peak Signal to Noise Ratio

In order to further evaluate the performance of this method, the Peak Signal-to-Noise Ratio (PSNR) is used to measure the quality of reconstructed sample frames of video signals.

| S/N | SAMPLE     | SIZE    | FRAME | PSNR   |
|-----|------------|---------|-------|--------|
| 1   | NAERLS1.avi | 18.1Mb  | 157   | 31.95Db|
| 2   | NAERLS2.avi | 10.3Mb  | 155   | 22.30dB|
| 3   | NTA1.avi   | 9.6Mb   | 152   | 17.71dB|
| 4   | NTA2.avi   | 11.2Mb  | 200   | 23.17dB|
| 5   | Akiyo.avi  | 11Mb    | 300   | 15.06dB|
| 6   | Foreman.avi| 7.25Mb  | 100   | 19.17dB|

The PSNR results of the black and white sampled video frame signals and coloured sampled video frame signals given in Table 2 were obtained from Figure 4 and Figure 8, respectively. In order to make a justifiable conclusion, the PSNR of the brightness enhancement technique on the coloured...
sample frames were determined as shown in Table 3. Note all tables in this section were computed from MATHLAB simulation environment R 2014a.

Table.3 Simulation Result of Performance Evaluation using PSNR on Coloured Frames.

| S/N | SAMPLE       | SIZE  | FRAME | PSNR  |
|-----|--------------|-------|-------|-------|
| 1   | NAERLS1.avi  | 18.1Mb| 157   | 36.45dB|
| 2   | NAERLS2.avi  | 10.3Mb| 155   | 26.65dB|
| 3   | NTA1.avi     | 9.6Mb | 152   | 24.45dB|
| 4   | NTA2.avi     | 11.2Mb| 200   | 28.90dB|
| 5   | Akiyo.avi    | 11.0Mb| 300   | 21.19dB|
| 6   | Foreman.avi  | 7.25Mb| 100   | 28.06dB|

The PSNR decibel values of Table 3 for the coloured frames show improvement when compared with their corresponding values in Table 2 for the hue and saturation free (black and white) frames. This indicates that, the brightness enhancement technique is more effective and efficient for coloured video than hue and saturation free frames. The bar chart in Figure 9 shows the amount of improvement on the coloured frames over the black and white frames.

Figure 9: Brightness Enhancement Comparison on Grey scale and Coloured Frames

Figure 9 shows the amount of brightness enhancement on the grey scale frames and the coloured frames. Both NAERLS1.avi and NAERLS2.avi coloured sample frames show a PSNR percentage improvement of 12.45% and 16.32% over the grey scale sampled images. The NTA1.avi and NTA2.avi coloured frames shows a PSNR percentage improvement of 27.57% and 19.83%, respectively. Similarly, the respective PSNR percentage improvement of 28.93% and 31.68% were achieved for Akiyo.avi and Foreman.avi benchmark video frames. This percentage improvement over the grey scale frames indicates the efficiency of this brightness enhancement method on coloured images. This is justifying the aim of this research work.
4. CONCLUSION
This research work developed a brightness enhancement technique for video frame pixel improvement based on pixel intensity analysis. A total of six (four acquired and two benchmark) sample data frames were used in the implementation and determination of the Improvement of the developed technique. Simulation results shows that the developed method is efficient with an improve pixel intensity and histogram distribution. The Peak to Signal Noise Ratio evaluation shows the efficiency and signal quality of the developed technique.

REFERENCES

Boon, C. S., Guleryuz, O. G. 2006 “Sparse super-resolution reconstructions of video from mobile Devices in Digital TV Broadcast applications” 5(1), pp 79- 88. Retrieved from http://eceweb.poly.edu/~onur/publish/san_diego_sr.pdf in March, 2014.

Ballabeni A., Apollonio F. L., Gaiani M., Remondino F. 2015 Advances In Image Pre-Processing To Improve Automated 3d Reconstruction. 3D Virtual Reconstruction and Visualization of Complex Architectures The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences. 1(1) pp.25-27

Brochier M. G., Vacavant A., Cerutti G., Kurtz C., Weber J., Tougne L. 2015 “Tree leaves extraction in natural images: Comparative study of pre-processing tools and segmentation methods” TRANSACTIONS ON IMAGE PROCESSING. Available at http://dx.doi.org/10.1109/TIP.2015.24002 14

B. O Sadiq, S. M Sani and S Garba (2015) “Edge Detection: A Collection of Pixel Based Approach for Coloured Images. International Journal of Computer and Applications (IJCA)”. 113(5) pp. 29 32

B. O Sadiq, S. M Sani and S Garba. “An Approach to Improving Edge Detection for Facial and Remotely Sensed Images Using Vector Order Statistics. International Journal of Multimedia and Its Application (IJMA). 7(1) pp. 17-25

Fan, Y. and Jin Wu., 2010 “An improved image contrast enhancement in multiple-peak images based on histogram equalization. IEEE International Conference Computer Design and Applications (ICCDA), 1(1), pp. 346

Garg R. And Kumar A. 2012 “Comparison of Various Noise Removals Using Bayesian Framework” International Journal of Modern Engineering Research (IJMER) 2(1), pp-265-270. Retrieved form www.ijmer.com

Ghodke, V. N. and Ganorkar, S. R. 2013 “Image Enhancement Using Spatial Domain Techniques and Fuzzy Intensification Factor” International Journal of Emerging Technology and Advanced Engineering. 3(1), pp 566-579.

Gwanggil Jeon 2014 “Color Image Enhancement by Histogram Equalization in Heterogeneous Color Space” p15-27. Retrieved from http://www.sersc.org/journals/IJMUE/vol_9_no7_2014/26.pdf in November, 2014.

Ian T. Young, Jan J. Gerbrands, Lucas J. vanVliet (1995) “Fundamentals of Image Processing” Delft University of Technology. Retrieved on 10th January, 2013 .http://www.google.com.ng/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0CBwQFjAA&url=http%3A%2F%2Frepository.tudelft.nl%2Fassets%2Fuuid%3A1d58e4e5 4a0365a0506808fcf2de82%2FI mageProcessingFundamentals.pdf&ei=T KyTVcO6NLDOQ7AbP_ruYAww&usg=AF QjCNGnGjif29x3QmLs_v_TJ3NwW3HL ktw&sig2=szlF3FTVdmeAdL6z2ZIHog.

Kamboj P. and Rani V. 2013 “A BRIEF STUDY OF VARIOUS NOISE MODEL AND
FILTERING TECHNIQUES”, Journal of Global Research in Computer Science, 4(4). REVIEW ARTICLE Available Online at www.jgrcs.info.

Keller, S. H., F. Lauze, 2013 “Video Super-Resolution using Simultaneous Motion and Intensity Calculations” 6(1), pp. 35-50. Retrieved from http://www.jpier.org/PIER/pier136/30.12110809.pdf in July, 2014

Keith, Jack “Video demystified fourth edition. A handbook for the digital engineer” ISBN: 978-0-7506-7822-3 copyright © 2005 Elsevier Inc. Retrieved on 17th May, 2014.

Li C., Xu C., Gui C., Martin D. 2010 “Distance Regularized Level Set Evolution and Its Application to Image Segmentation” IEEE TRANSACTIONS ON IMAGE PROCESSING, 19(12). Retrieved from scholar.google.com

Li C., Huang R., Ding Z., Gatenby J.C., Metaxas D. N., Gore J. C. 2011 “A Level Set Method for Image Segmentation in the Presence of Intensity Inhomogeneities With Application to MRI” . IEEE TRANSACTIONS ON IMAGE PROCESSING. 20(7). Retrieved from scholar.google.com

Padmavathi S. Priyalakshmi I. B. Soman K. P. 2012 “HIERARCHICAL DIGITAL IMAGE INPAINTING USING WAVELETS” Signal & Image

Pandey A. K., Agarwal K., Haroon M. 2015 “A Hybrid Approach for Enriching Image using Mamdani Neuro-Fuzzy Technique and its Comparative Analysis”, International Journal of Computer Applications, 121(19) pp.23-35

Processing: An International Journal (SIPIJ). Vol.3(4). Retrieved from scholar.google.com

Roopashree.S, Sachin S. Rohan R. S. 2012 “Enhancement and Pre-Processing of Images Using Filtering” International Journal of Engineering and Advanced Technology (IJET) 1(5). Retrieved from scholar.google.com

Siddavatam R., Sood A., Jayasree S. P., Ghrera S. P. 2011 “An Intelligent Recursive Algorithm for 95% Impulse Noise Removal in Grayscale and Binary Images using Lifting Scheme” Proceedings of the World Congress on Engineering and Computer Science, 1(1), pp19-21

Verma R. and Ali J. 2013 “A Comparative Study of Various Types of Image Noise and Efficient Noise Removal Techniques”. International Journal of Advanced Research in Computer Science and Software Engineering. Available online at: www.ijarcsse.com

Vishwakarma, A. K. and Mishra, A. 2012 “Color Image Enhancement Techniques: A Critical Review” Indian Journal of Computer Science and Engineering (IJCSE), 3(1) pp.554-678

Zhang D., Liang J. I., Singh I. 2013 “Fast transmission distortion estimation and adaptive error protection for H.264/AVC-based embedded video conferencing systems” 25(5), pp417-429.