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Image Enhancement by Correction of Cllipped Pixels: An Exemplification

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Abstract

Conventional images store an extremely constrained element scope of brightness. The genuine luma in the bright region of such pictures is regularly lost because of section. At the point when section changes the R, G, B shading ratios of a pixel, shading twisting likewise happens. In this paper, we propose an algorithm to improve both the luma and chroma of the clipping pixels. Our method is in view of the solid chroma spatial connection between clipping pixels and their encompassing unclipped zone. In the wake of distinguishing the clipping ranges in the picture, we segment the clipping regions into districts with comparative chroma, and gauge the chroma of each clipping area in light of the chroma of its encompassing unclipped locale. We rectify the clipping R, G, or B shading channels taking into account the evaluated chroma and the unclipped shading channel(s) of the present pixel. The next step includes smoothing of the boundaries between regions of different clipping scenarios. And, lastly the brightness of clipped boundary pixels are adjusted on the basis of value of pixels odd never regions. Both goal and subjective exploratory results demonstrate that our algorithm is exceptionally viable in restoring the chroma, luma, and brightness of clipped pixels.

Keywords: *Clipping, desaturation, color restoration, high dynamic range (HDR), inverse tone mapping*

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INTRODUCTION

Due to innovative headways in the field of image processing, high dynamic range (HDR) shows have increased critical enthusiasm for industry. It is realized that the dynamic scope of routine showcases is exceptionally limited compared to the range of intensities perceivable by the human vision system. Lineal displays normally have a dynamic range of about two orders of magnitude, whereas the human visual system has an overall dynamic range of nearly 10 orders of magnitude, and can also perceive intensities over a range of about five orders of magnitude [1, 2]. This has motivated the improvement of HDR image capturing and display technology. In this survey paper we consider the problem of HDR content and proper method to display them on a conventional low dynamic range (LDR) media. Tone reducing so as to map addresses this issue solid contrast from the HDR scene qualities to the LDR displayable range while preserving the image details and color appearance that are important to appreciate the original scene content. When utilizing CMOS innovation for image sensors, there is a plausibility that any given pixel is imperfect and will in this manner deliver a quality that does not connect to the measure of light it was liable to. Thusly, the processing unit will calculate a value that differs from the value produced if the transistor was working correctly. Having a pixel with a blemished quality can show itself as a light spot or a dark spot depending on whether the transistor for that pixel is on or off. In a few zones where the estimation of the damaged pixel does not vary significantly from its neighbors, the image won't show up as corrupted according to the viewer as though the imperfect quality was in awesome contrast to its environment. The capacity to adjust for the blemished pixels with an algorithm will result in a more robust device that is not required to function perfectly in order to produce an image. It additionally deciphers into profit as an organization can offer image sensors that would somehow have been disposed of by testing procedures. Conventional image stores an exceptionally constrained element scope of brightness. The genuine luminance in the bright zone of such images is regularly lost because of clipping. At the point when clipping changes the color ratio of a pixel, it also results in color distortion. Defective pixels are caused by an error in the fabrication of the image sensor that translates into a transistor being either static on or static off and will accordingly translate into the CPU interpreting false value from the pixel. The next part of the paper will describe how defective pixels can show themselves on an image, and variables involved in the detecting and correcting algorithm.

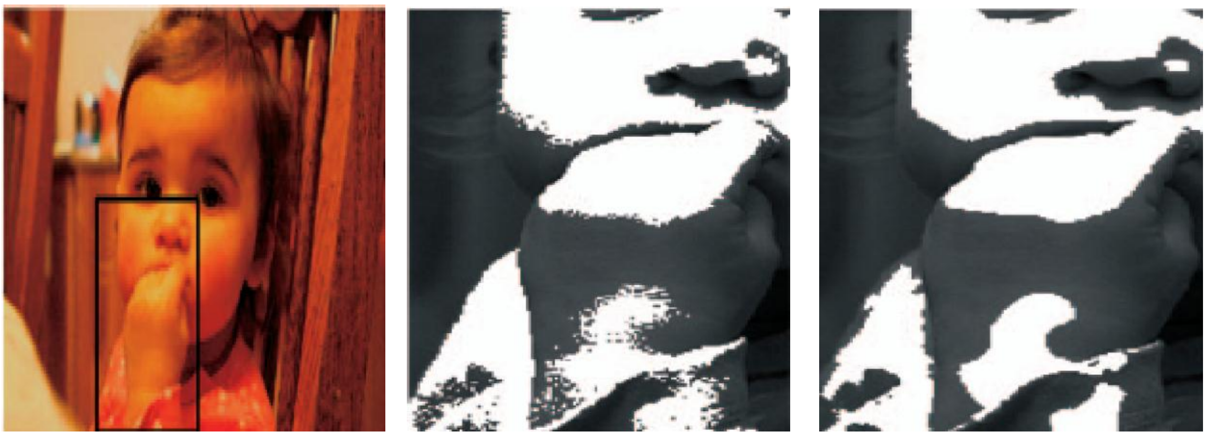
TECHNIQUES

Identify Clipped Areas

Before doing any enhancement, we first need to identify the clipped areas. One method for doing this is to just select pixels from all three color channels that have the maximum value (e.g., 255 for 8-bit per channel images). Figure 1(a) shows a clipped image with a rectangular region of interest. Figure 1b shows the clipped area (within the region of interest) identified with a simple threshold (the maximum value, e.g., 255 for 8-bit per channel images). The white pixels speak to the clipped zone. As it can be seen, this straightforward approach regularly produces little isolated clipped ranges and huge clipped zones with small holes. The effect is due to image noise. The captured pixel values are determined not only by the light from the scene, but also by the camera response, sensor noise, what's more, color filter array interpolation. The in-camera handling adds noise to a pixel value, and thus, a clipped pixel might have a worth marginally lower than the maximum value. Hence, we first apply a bilateral filter to remove the noise. Then, a threshold τ is connected to every color channel of a pixel to recognize clipped pixels and channels. We experimentally selected τ to be 252.5 for 8-bit per channel images herein. Figure 1c demonstrates the clipped range in the district of interest distinguished by our system. We watch that the clipped zone in Figure 1c is quite clean and more appropriate for subsequent color correction compared to that in Figure 1b. Note that the bilateral filter is utilized just to identify the clipped areas. The first unfiltered image is utilized as a part of all of the accompanying strides to abstain from losing detail from the image.

Partition Clipped area

The purpose of partitioning the clipped areas is to bunch the clipped pixels into areas with comparable chroma before correcting the color for each region. We first segment the clipped areas into spatially disengaged regions, which probably belong to different surfaces and have different chroma. Every region might at present contain numerous clipped protests that have diverse colors. We section every region as indicated by its chroma. To eliminate the illumination differences on the same color surface, we consider only chroma quantities, i.e., Cb and Cr, in the segmentation. For simplicity to section the area, we utilize either the Cb or Cr, whichever has a bigger fluctuation inside of the considered region.



(a) *(b)* *(c)*

Fig. 1: *Example of Clipped Images;* ***(a)*** *Image Clipped with Rectangular Area of Interest,* ***(b)*** *Clipped Area Identified with a Simple Threshold,* ***(c)*** *Clipped Area of Interest Identified with Our Proposed Approach [3].*

Correct Chroma

As explained before, the R, G, and B values are strongly affected by the illumination of the area. There are much more grounded spatial variations in R, G, and B values than in chroma. Although the RGB also, chroma in clipped areas can both be assessed utilizing an introduction system given their neighboring unclipped areas, a smooth sign, similar to the chroma, might be all the more precisely evaluated, subsequent to there is less spatial variation associated with such a signal. Thus, we assessed the chroma values in a clipped region by easily adding the chroma of neighboring clipped pixels. Once the chroma values are estimated, then we use them to calculate the corrected R, G, or B values in the clipped regions. To redress a clipped region, we first endeavor to locate an unclipped area with comparable chroma beside it. We select neighboring pixels with comparative color to the clipped region as seed focuses.

This is finished by first picking the unclipped or already corrected neighboring pixels with gradients of both chroma channels less than a threshold. Then, beginning from every seed point, we apply a region developing algorithm shown by Tsai *et al.*, to both Cb and Cr, and the crossing point of the two acquired regions is an encompassing regions with comparative chroma to the clipped regions [4]. Subsequently, there might be little chroma varieties inside each clipped region, we take the union of every single encompassing areas got from various seed focuses as the encompassing region for a clipped region. If the resulting surrounding region consists of only very few pixels, then the clipped region is considered as a light source or a secularly reflected area. The Cb and Cr estimations of the clipped region could be introduced from its encompassing region. An issue emerges from the way that the encompassing regionis unpredictably shaped with some missing pixels, which cannot be used in the interpolation because they are either clipped pixels or non-clipped pixels with different chroma to the current clipped region. A common interpolation approach is to use convolution (filtering). However, traditional convolution does not work when there are missing examples inside of the convolution veil. For the reason expressed above, we utilized standardized convolution rather, which takes into account missing specimens by conforming the channel weights to utilize just the legitimate examples that fall inside of the convolution cover [5]. The thought of standardized convolution is to associate with each pixel a certainty component m expressing the level of confidence in the pixel measurement. The certainty map m has the same dimension as the image.

To make the examination more applicable to our issue within reach, that is, interjecting chroma for soaked pixels, the standardized convolution can be expressed as follows:

$$\check{c}(x,y) = \frac{[c(x,y).m(x,y)] * h(x,y)}{m(x,y) * h(x,y)}$$

Where the certainty map m(x, y) is 1 for the known pixels that are used in the interpolation and m(x, y) is 0 for the missing samples. The c(x, y) and č(x, y) represent the chroma channel signal (Cb or Cr) before and after the convolution, and h(x, y) denotes the filter for performing the convolution. Here, a Gaussian filter with a standard deviation 5 is used as the function h(x, y).

The normalized convolution mask h(x, y) has a finite size. Consequently, a pixel situated close to the focal point of the clipped region might not have any pixel in the encompass region lying in its veil. Subsequently, the pixel esteem can't specifically be amended. Keeping in mind the end goal to take care of this issue, we utilize the officially amended clipped pixels together with the encompassing locale as the known information for assessing the uncorrected clipped pixels. At the end of the day, the assurance map utilized is:

m(X,Y)={1,for unsaturated pixels in the surrounding region and saturated pixels that has been corrected 0,otherwise.

This helps improve the smoothness of the corrected chroma in the clipped region. Since already corrected pixels are used in the normalized convolution, the pixel order within a clipped region is very important. Because estimation error could propagate, the pixels with potentially less error should be corrected first.

Correct RGB Values

If We calculate the missing R, G, or B values in each clipped region based on the estimated Cb and Cr values (calculated and the unsaturated R, G, or B values in that region. We expound this revision process for the accompanying three distinct situations corrected of 2-channel saturated pixels is the most straight forward scenario. We know that the conversion from RGB to YCbCr,

$$\left[\frac{Y}{\frac{Cb}{Cr}}\right] = \left[\frac{0.2568 \quad 0.5041 \quad 0.0979}{\frac{-0.1482 \ -0.2910 \ \ 0.4392}{0.4392 \ -0.3678 \ -0.0714}}\right] \times \left[\frac{R}{\frac{G}{B}}\right] + \left[\frac{0.0627}{\frac{0.5020}{0.5020}}\right]$$

The above RGB and YCbCr values are within a range of 0.0–1.0.

Cb=[–0.1482–0.2910 0.4392×[R G B]^T+0.5020,

Cr=[0.4392–0.3678–0.0714]×[R G B]^T+0.5020,

When two channels are clipped, then one of the R, G, and B values, say, U (which stands for the unsaturated channel), is known and the two clipped channels, say, S1 and S2 (which stand for the saturated channels), are unknown and need to be solved for. The U; S1, and S2 are all components in the three color channels [R, G, B]. The corrected value of the two soaked channels can be exceptionally understood for utilizing the two mathematical statements (3) and (4). Along these lines, we have:

$\check{S}_1 = f_1$ (U, Cb, Cr),

$\check{S}_2 = f_2$ (U, Cb, Cr).

Where f1 and f2 are functions of U, Cb, and Cr, and ~S denotes the corrected value of color channel S. Note that we do not use Y to correct the RGB color channels, since Y is distorted when any color channel is clipped. The functions f1 and f2 can be derived uniquely from the RGB to YCbCr conversion Eq. (3) and (4). As an example, let us consider a case where R and G are the two clipped unknown channels in a saturated pixel, and B is the unclipped channel. From Eq. (3) and (4), we can solve for ~R and ~G given Cb, Cr, and B as follows:

$\check{R}$=[(Cb–0.5020–0.4392B)×(–0.3678)–(Cr–0.5020–0.0714B)×(–0.2910)]/[(–0.1482)×(–0.3678)–0.4392×(–0.2910)]

$\check{G}$=[(Cb–0.5020–0.4392B)×0.4392–(Cr–0.5020–0.0714B)×(–0.1482)]/[(–0.2910)×0.4392–(–0.3678)×(–0.1482)]

Any other 2-channel saturated pixels can be corrected in the same fashion.

Smooth Enhancement

The main purpose of color enhancement is to obtain visually plausible images and videos. Regularly, there are little bounced of upgraded qualities between nearby 1, 2, and 3-channel saturated regions. This is because different strategies are used for Ώ1, Ώ2, and Ώ3 when calculating saturated RGB channels from the corrected Cb and Cr. As a result, a smoothing process near the region boundaries of Ώ1, Ώ2, and Ώ3 is expected to reduce disturbing contours and get common looking enhanced images.

Correct Brightness

Our technique works well when a saturated region is associated with an unsaturated surrounding region with similar chroma. In some cases, no such surrounding region can be found, and our method cannot be utilized to estimate the chroma in the clipped region. The brightness of clipped pixels is adjusted on the basis of pixels of never regions of clipped area and brightness is approximated according to pixels falling in never regions.

PROPOSED APPROACH

In this piece of work, we aim at restoring the lost data in overexposed shading image in light of the solid spatial correlation in the chroma channels along with brightness based on never pixels of clipped image. The YCbCr shading space is composed so that the chroma channels will be smooth in local regions for most images. It has been demonstrated that using the smoothness property of chroma is superior to anything expecting luma is smooth. Figure 2 below shows the normalized autocorrelation of R, G, B, Y, Cb, and Cr at lags of 0–25 pixels. Each point in the figure is an average value over the 24 true-color Kodak images [6]. From the graph, we can see that there is stronger autocorrelation for the Cb and Cr channels than the R, G, B, and Y channels. Exploiting the strong spatial correlations in the Cb and Cr channels has more potential than exploiting the correlations in the R, G, B, or Y channels. Hence, in our methodology, we apply a chroma interpolation for the clipped pixels instead of specifically remedying the R, G, and B signals.

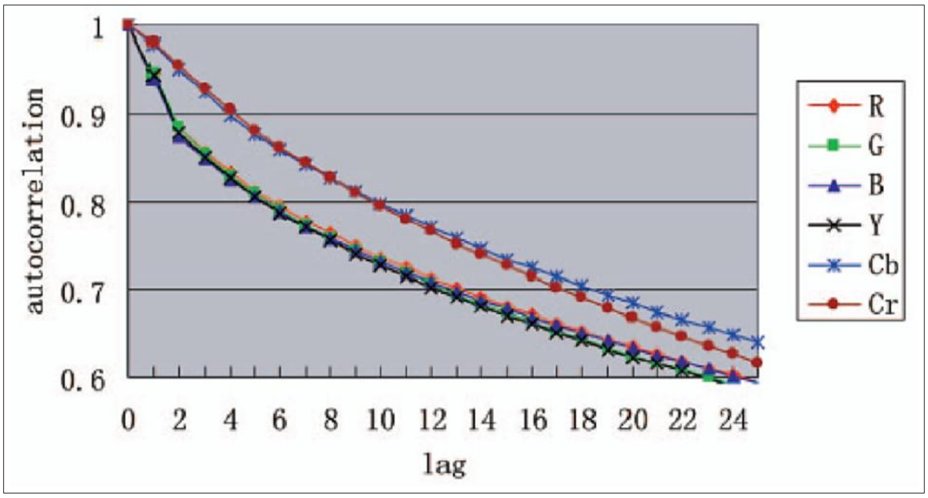
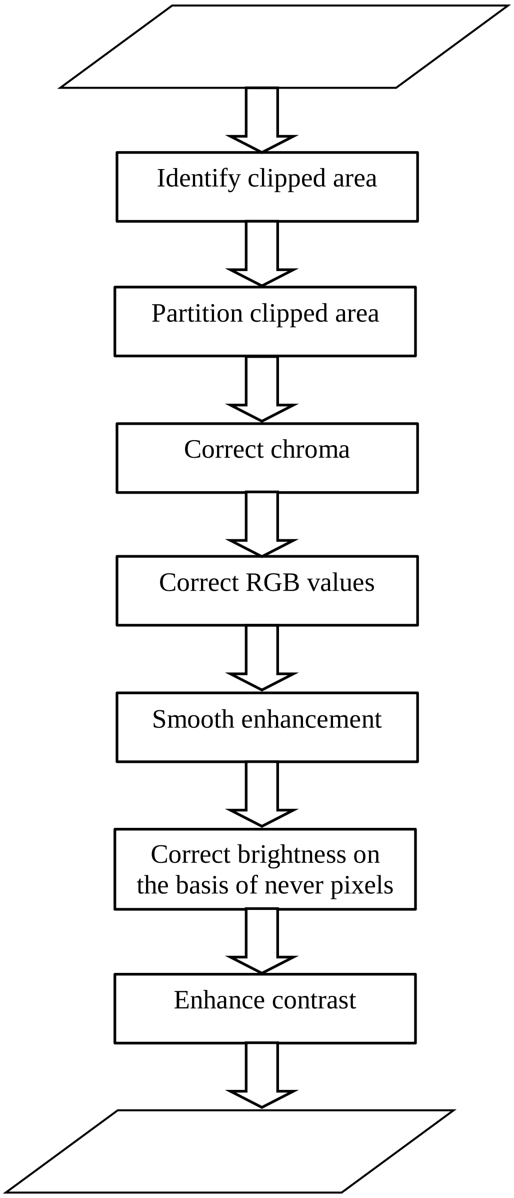


Fig. 2: *Normalized Auto-Correlation of R, G, B, Y, Cb, Cr Signals [36].*



Our proposed strategy can be separated into a few stages, which are appeared in the flowchart in Figure 4. Initially, we distinguish the clipped ranges. At that point, we parcel each clipped region into littler regions as per the chroma. We redress the chroma for every regionand after that right the relating RGB values for every single clipped pixel. A while later; we apply a smoothing procedure to the amended RGB values. The last step includes the enhancing of the contrast, what's more, can be performed by utilizing any current inverse tone mapping process [7–9], which is not the center of our work. A point by point portrayal description of these steps is given in the following part of the paper [10].

RESULTS

In this segment, we exhibit some trial results to demonstrate the adequacy of our proposed technique for upgrading the clipped pixels. We utilize customary 24 bits for every pixel LDR color images for our tests. Thumbnails of our test images are demonstrated as follows. In our trial, we create the clipped images by clipping the R; G; B values that are more prominent than a limit (e.g., 255 X 0.8 for 8 bits for every color channel images). At that point, we improve the clipped images utilizing our proposed strategy and also the Bayesian algorithm [11], the main color correction algorithm for clipped pixels that we know about. To evaluate the nature of the corrected images, we compute the peak signal-to-noise ratio (PSNR) values (averaged over R; G; and B channels) of each test image for:

1) The clipped image with no correction,
2) The enhanced image generated by the Bayesian algorithm, and
3) The enhanced image produced by our proposed algorithm.

Below expounded are the experimental results with test images:

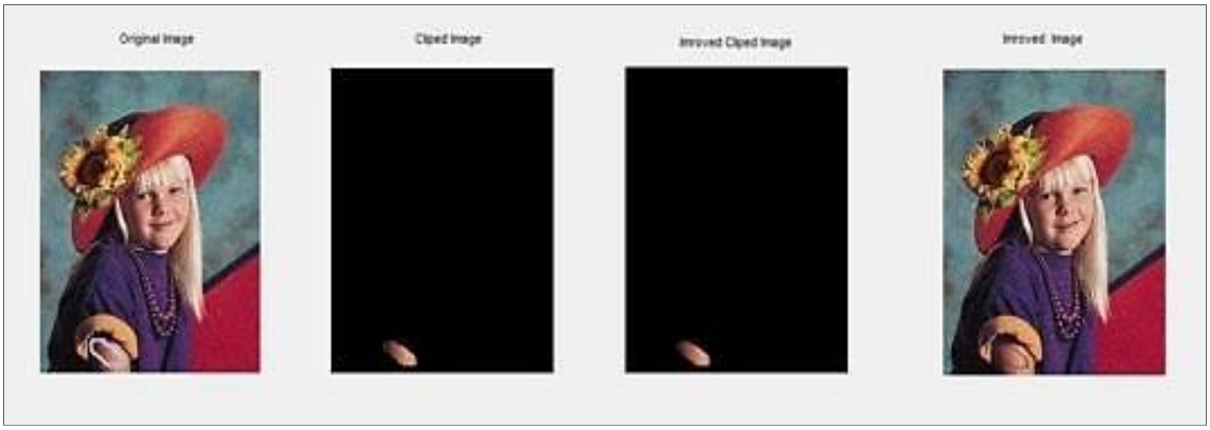


Fig. 4: *Experimental Screenshot 3 (After Clipping, and Enhancement) with PSNR 38.968285.*

Table 1: *Comparison of PSNR (in dB) for Existing and Proposed Approach.*

Image	PSNR (dB)			
	Clipped	Bayesian	Existing Approach	Proposed Approach
Girl	42.23	39.70	50.68	52.01
Landscape	25.66	28.69	29.53	30.50
Baby girl	32.15	29.06	36.40	37.20
Mountain	29.98	34.27	37.02	38.06
Sunset	21.73	20.76	27.18	28.32
Lake	35.07	35.85	41.74	42.86

In the very similar way, to evaluate the competency of the proposed approach, we calculated PSNR (in dB) for various set of test images and compared it for clipped image directly, after applying Bayesian algorithm, after implementing existing approach and then compared with proposed approach, table for the same is shown table 1. Graphical evaluation for Table 1 of experimental results is shown below:

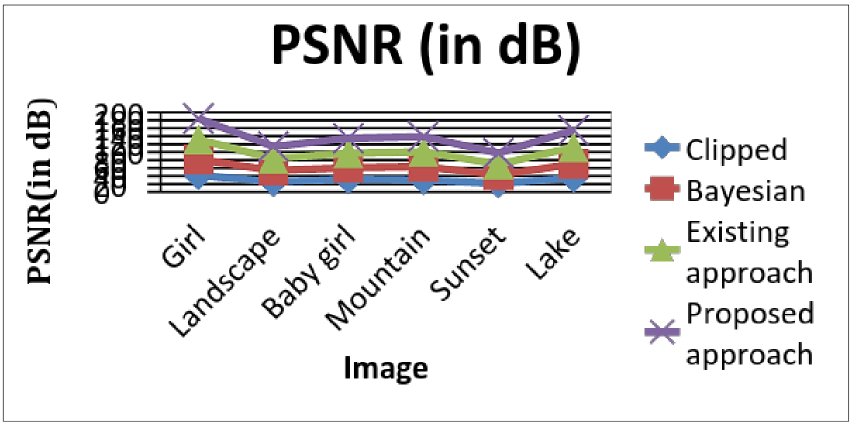


Fig. 5: *Graphical Evaluation of Experimental Results as Shown in Table 1.*

So it is obvious from above shown results that proposed approach outperforms Bayesian approach as well as existing approach for the same with an average PSNR drawing to 38.158 dB Temperature/K.

CONCLUSION

The work proposed above is actually meant for the purpose of image enhancement through correction of clipped pixels. Here is an effective technique for improving clipped pixels in color images. We take point of preference of the solid correlation between the chroma of the clipped pixels and their encompassing unclipped pixels. Our technique significantly reduces the color distortion caused by clipping. It also effectively corrects the luma of pixels in the clipped areas in addition to brightness and outperforms Bayesian as well as existing approach for the same. Subjective results likewise demonstrate that the improved images created by our strategy are outwardly more conceivable than the clipped images and the improved images produced by the Bayesian algorithm. Other research areas can be benefited from the color correction for clipped pixels. We showed that by applying inverse tone mapping to LDR images that have been enhanced by our method, we obtain more plausible and realistic HDR images than applying inverse tone mapping directly to the clipped images. Since color has been generally utilized as a part of machine-based vision frameworks, our algorithm might likewise build the execution of assignments, for example, color-based image segmentation, object recognition, tracking, panoramic images generating, and multiview image processing.

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