INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH & DEVELOPMENT

ISSN: 2278 – 0211 (Online)

# "Development Of Algorithm For High Resolution Retinex For Image Enhancement"

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***Abstract:***
*Retinex is a method used for image processing. Image processing has a great role in Medical science. Medical images such as MRI, CT, Ultrasound, X-Ray has to be processed for proper diagnosis. Retinex technique can be used for the processing of these images. By retinex processing it can provide better dynamic range compression, color consistency and lightness rendition. The different methods proposed by retinex algorithm includes Light Compensation Algorithm in Color Facial Image, Retinex for bridging the gap between color images and the human observation of scenes, Color Image Contrast Enhancement by Retinex, Color Image Enhancement with Adaptive Filter. In this paper we discuss about an algorithm for frequency domain based high resolution retinex for medical image processing. Initially we introduce Fast Fourier Transform to the image. Then Gaussian filtering is done and the inverse fourier transform is taken. Next step is to apply logarithmic function. Finally gain/offset is applied to obtain the enhanced output image. The method can produce good contrast enhancement. It can be used for both color image and gray image. Since it can process gray images the medical images can be processed successfully. The output for Single Scale Retinex, Multi Scale Retinex and Multi Scale Retinex with Color Restoration are obtained.*

***Keywords:*** *retinex, dynamic range compression, colorconsistency, Gaussian filtering,multi-scale retinex, multi scale retinex with color restoration, single-scale retinex,*

## 1.Introduction

Image enhancement is a method for improving the quality of images for human visualization. Removing blurring and noise, increasing contrast and revealing details are examples of enhancement operations. Medical images, such as CT images and magnetic resonance images, always suffer from poor contrast due to their imaging techniques [1]. Therefore, it is very necessary to enhance the contrast of such images before further processing and analysis.

Retinex algorithm can be used for medical image processing. The idea of Retinex was conceived by Edwin Land [2] as a model of lightness and color perception of the human vision. Obviously it is not only a model, but also could be developed to algorithms of image enhancement. Edwin Land coined word for his model of human color vision, combining the retina of the eye and the cerebral cortex of the brain. Edwin Land introduced a center/surround spatial form, which was inspired by the receptive field structures of neurophysiology. The Retinex is a human-perception based image processing algorithm which provides color constancy and dynamic range compression.

Daniel J. Jobson et al. has proposed multiscale retinex [3], which fills the gap between color images and the human observation of scenes. The enhanced image has good dynamic range compression and color constancy but this method fails to produce good color rendition.

Youhei Terai et al. [4] proposed a retinex model for color image contrast enhancement. The luminance signal is processed to reduce the computation time without changing color components. But the computation time of this approach is still large due to large scale Gaussian filtering. The algorithm performs better for gray images rather than color images.

A color image enhancement algorithm based on human visual system based on adaptive filter is proposed by Xinghao Ding et al. [5]. The algorithm utilizes color space conversion to obtain a much better visibility. The algorithm has better effectiveness in reducing halo and color distortion. However, the algorithm may not be efficient from computation point of view.

Yali Feng et al [6] introduced the fast Fourier algorithm into the original algorithm to make the speed faster than that of the traditional method. Then next adjust the image by gain/offset. The method is good for color images but not for gray images.

Our paper discuss about the contrast enhancement of medical images using retinex algorithm. It can correct the blurring in deep anatomical structures and inhomogeneity present in medical images. Initially we introduce Fast Fourier Transform to the image. Then Gaussian filtering is done and the IFFT is taken. Next step is to apply logarithmic function. Finally gain/offset is applied to obtain the enhanced output image. The method can produce good contrast enhancement. It can be used for both color image and gray image. Since it can process gray images the medical images can be processed successfully. The output for Single Scale Retinex, Multi Scale Retinex and Multi Scale Retinex with Color Restoration are obtained.

## 2.Retinex Theory

A human observer can easily see individual objects both in the sunlight and shadowed areas, since the eye locally adapts while scanning the different regions of the scene. When attempting to display the image on a display, either the low intensity areas are underexposed and look black or the high intensity areas are overexposed and cannot be seen. This problem of Color Constancy in images is solved using the basis of Retinex Theory [7].

In this section, we will give a brief description of major categories of Retinex approach. There are Single Scale Retinex (SSR) [8] and Multi Scale Retinex (MSR). In SSR instead of applying logarithmic function on the image in order to enhance the range of image signal value, the image signal is passed through the Gaussian filter kind of system called retinex filter. The output of the retinex filter is used only for scaling the original image signal such that the pixel values are scaled by different amounts depending upon the filter output. The scaled down image is then processed with logarithmic function. Since image filtering using retinex function may require different Gaussian shaped impulse response with different variance MSR approach is used.

SSR mathematically expressed [9] as,

$$R_i(x_1, x_2) = \log\left(I_i(x_1, x_2)\right) - \log\left(I_i(x_1, x_2) * F(x_1, x_2)\right) \qquad (1)$$

F is a Gaussian filter defined by

$$F(x_1, x_2) = k\exp\left[-({x_1}^2 + {x_2}^2)/\sigma^2\right] \qquad (2)$$

The MSR can be written as [10],

$$R_i(x, y) = \sum_{k=1}^{K} W_k . \{\log[I_i(x, y)] - \log[I_i(x, y) * F_k(x, y)]\} \qquad (3)$$

Surround function is,

$$F_k(x, y) = K\ \exp[-(x^2 + y^2)/{\sigma_k}^2] \qquad (4)$$

The MSR algorithm [11] is a tone-reproduction operator which can achieve color/lightness rendition and dynamic range compression simultaneously. It estimates scene reflectance from the ratios of scene intensities to their local intensity averages. First, the scene is decomposed into a set of images that represent the mean of the image at different spatial resolutions by applying Gaussian filters of different sizes. Next, a set of images that measure the scene reflectance is produced by dividing the original picture point wise by the decomposed picture. Then, a log function is applied to each of the images to reduce the image dynamic range. Finally, the displayed image is reconstructed by adding the compressed images together. In both the approaches the color images get badly affected when the luminance portion of the image is passed through retinex filter, hence post processing has to be done for the retinex filtered color images by using different color restoration procedures.

MSRCR is mathematically given as

$$R_i(x_1, x_2) = \alpha_i(x_1, x_2) \sum_{k=1}^{K} W_k( \log I_i(x_1, x_2) - \log[F_k(x_1, x_2) * I_i(x_1, x_2)]) \qquad (5)$$

Multi Scale Retinex with Color Restoration (MSRCR) [12] is better approach for color images. Computation like the MSRCR appears to have two very useful properties simultaneously: a diminishment in the dependence of the appearance of the image on extraneous variables such as spatial and spectral lighting, and the construction of compact context relationships. The advantage of retinex enhancement is that it has general application on all pictures, good dynamic range compression and color rendition effect and also canonical constant.

## 3.Proposed High Resolution Retinex Algorithm

### *3.1.Single Scale Retinex*

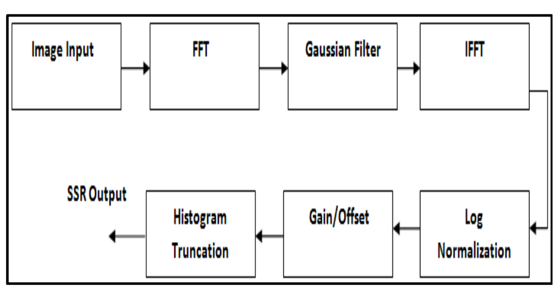



*Figure 1: Block Diagram of SSR*

Fast Fourier Transform is applied to the input image. Then Gaussian filter is used for filtering and inverse fourier transform is taken. Next the output undergoes logarithmic processing so that the dynamic range of the image can be compressed by replacing the image pixel values with its logarithm; by this the low intensity values can also be enhanced. Next gain and offset is applied so that the gain adjusts the bright part of the image and offset adjust the dimmer part of the image. Finally histogram truncation is done which allows the gray levels to be distributed to the primary part of the histogram so it solves the problem when one says a few bright values in the image have the overall effect of darkening of rest of the image after rescaling.

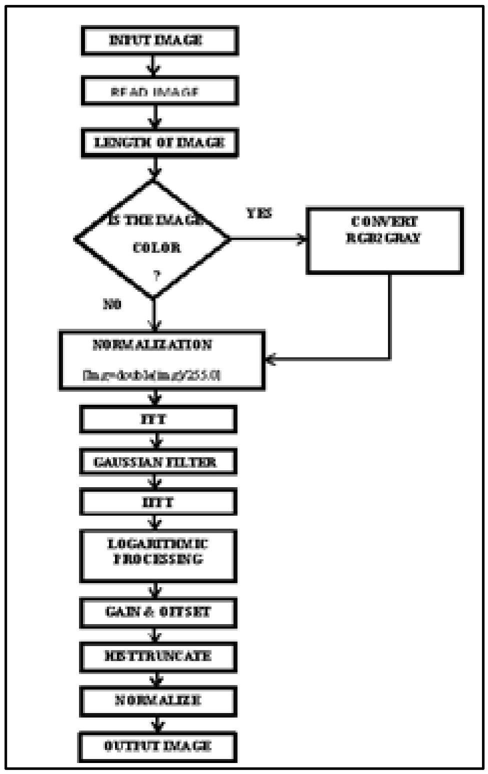
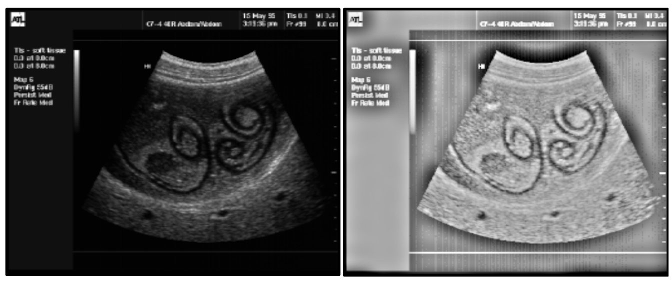



*Figure 2: SSR flowchart for black & white image*

- Step 1: Input image and read the image. Image read as array of values.
- Step 2: Obtain length of the image array. If the length is 2 then it is gray image so it can go for further processing. If the length is 3 then it is color image so it has to be converted to gray and go for next step.
- Step 3: Normalization done so that image pixel values are converted to a range of 0-1.
- Step 4: Fast Fourier Transform is obtained

- Step 5: Gaussian filtering is done along with particular surround function constant ie; 15 or 80 or 200
- Step 6: Inverse fourier transform is taken.
- Step 7: Logarithmic processing is done so that low intensity pixel values will also get enhanced.
- Step 8: Apply gain=0.35 and offset=0.65
- Step 9: Histtruncate function will truncate a specified percentage of lower and upper ends of the image histogram. Clip values are 0.6 each.
- Step 10: Normalize pixel values so that the minimum value of the array is mapped to 0 and maximum to 255.
- Step 11: Enhanced output image is obtained.



(a) (b)

*Figure 3: ultrasound image (a) original image (b) output image*

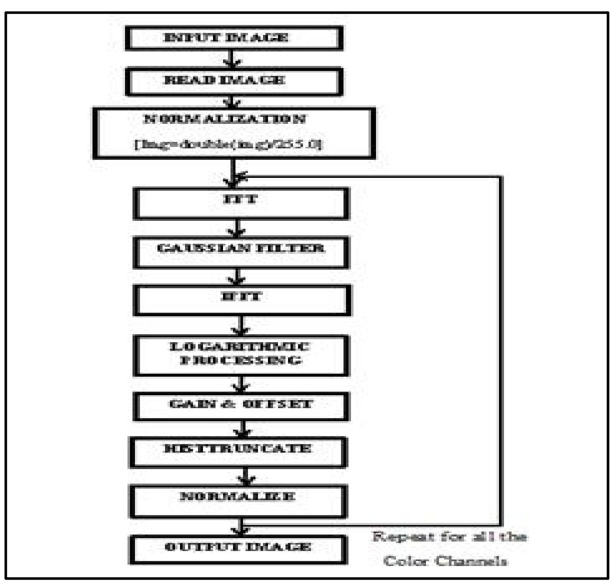
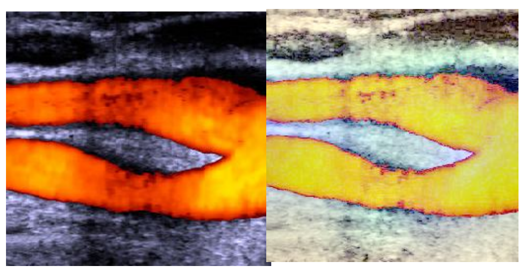



*Figure 4: SSR flowchart for color image*

- Step 1: Input image and read the image. Image read as array of values.
- Step 2: Normalization done so that image pixel values are converted to a range of 0-1.
- Step 3: Fast Fourier Transform is obtained
- Step 4: Gaussian filtering is done along with particular surround function constant ie; 15 or 80 or 200
- Step 5: Inverse fourier transform is taken.
- Step 6: Logarithmic processing is done so that low intensity pixel values will also get enhanced.
- Step 7: Apply gain=0.35 and offset=0.65
- Step 8: Histtruncate function will truncate a specified percentage of lower and upper ends of the image histogram. Clip values are 0.6 each.
- Step 9: Normalize pixel values so that the minimum value of the array is mapped to 0 and maximum to 255.
- Step 10:Step 3 to Step 9 is repeated for red green and blue color channel.
- Step 11: Enhanced output image is obtained.



(a) (b)

*Figure 5: Color Doppler (a)original image (b)output image*

*3.2.Multi Scale Retinex*

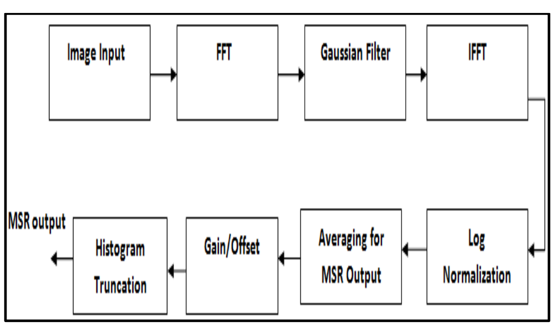



*Figure 6: Block Diagram of MSR*

Fast Fourier Transform is applied to the input image. Then Gaussian filter is used for filtering. Gaussian filtering is done along with three surround function constants 15, 80 and 200 so there will be three outputs. Inverse fourier transform of these outputs will be taken. Next the output undergoes logarithmic processing so that the dynamic range of the image can be compressed by replacing the image pixel values with its logarithm; by this the low intensity values can also be enhanced. Then the averaging of the output is done. Finally histogram truncation is done which allows the gray levels to be distributed to the primary part of the histogram.

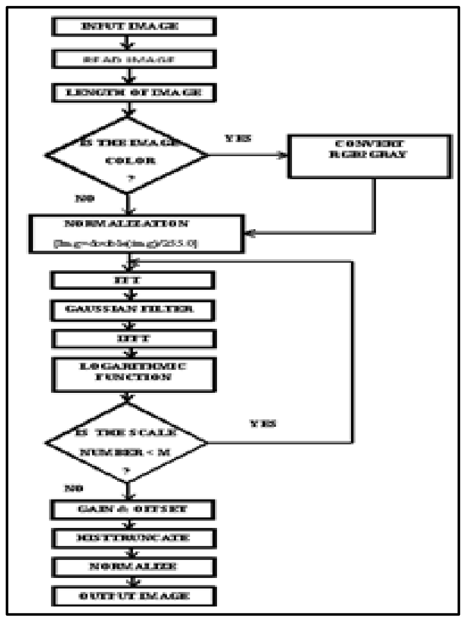
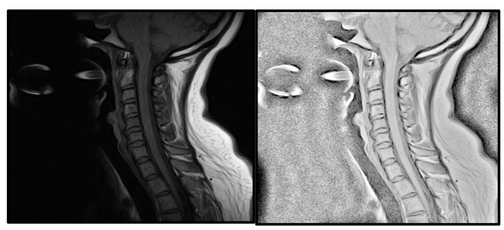



*Figure 7: MSR flowchart for black & white image*

- Step 1: Input image and read the image. Image read as array of values.
- Step 2: Obtain length of the image array. If the length is 2 then it is gray image so it can go for further processing. If the length is 3 then it is color image so it has to be converted to gray and go for next step.
- Step 3: Normalization done so that image pixel values are converted to a range of 0-1.
- Step 4: Fast Fourier Transform is obtained
- Step 5: Gaussian filtering is done along with particular surround function constant ie; 15, 80 & 200
- Step 6: Inverse fourier transform is taken.

- Step 7: Logarithmic processing is done so that low intensity pixel values will also get enhanced.
- Step 8: It will check whether the 3 scale values processing is completed or not. If not completed then goes to Step 4 and repeat the procedure else goes to next step
- Step 9: Apply gain=0.35 and offset=0.65
- Step 10: Histtruncate function will truncate a specified percentage of lower and upper ends of the image histogram. Clip values are 0.6 each.
- Step 11: Normalize pixel values so that the minimum value of the array is mapped to 0 and maximum to 255.
- Step 12: Enhanced output image is obtained.



(a) (b)

*Figure 8: X-Ray (a)original image (b)output image*

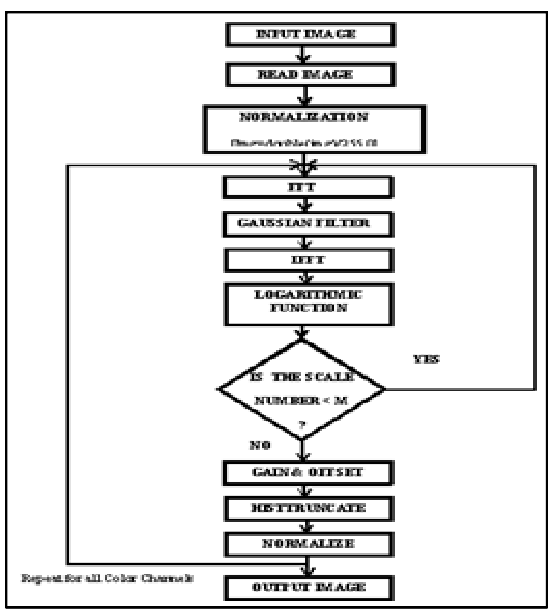
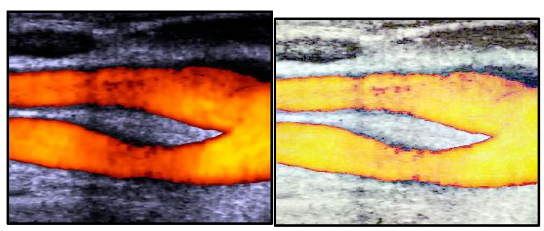



*Figure 9: MSR flowchart for color image*

- Step 1: Input image and read the image. Image read as array of values.

- Step 2: Normalization done so that image pixel values are converted to a range of 0-1.
- Step 3: Fast Fourier Transform is obtained
- Step 4: Gaussian filtering is done along with particular surround function constant ie; 15, 80 & 200
- Step 5: Inverse fourier transform is taken.
- Step 6: Logarithmic processing is done so that low intensity pixel values will also get enhanced.
- Step 7: It will check whether the 3 scale values processing is completed or not. If not completed then goes to Step 3 and repeat the procedure else goes to next step
- Step 8: Apply gain=0.35 and offset=0.65
- Step 9: Histtruncate function will truncate a specified percentage of lower and upper ends of the image histogram. Clip values are 0.6 each.
- Step 10: Normalize pixel values so that the minimum value of the array is mapped to 0 and maximum to 255.
- Step 11:Step 3 to Step 10 is repeated for red green and blue color channel.
- Step 12: Enhanced output image is obtained.



(a) (b)

*Figure 10: Color Doppler (a)original image (b)output image*

*3.3.Multi Scale Retinex With Color Restoration*

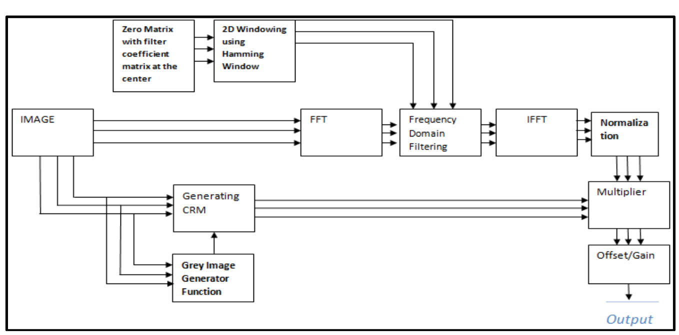



*Figure 11: Block Diagram of MSRCR*

Generate grey image out of the color image and obtain the each color channel information out of the color image. Next generate the Color Restoration Matrix (CRM) for each channel. A zero matrix is generated with the same size as that of the image. At the center of the zero matrix a 21x21 Gaussian filter is created and placed surrounded by zeros of the zero matrix. Two dimensional windowing is done for the above filter matrix to smoothen the edges of the 21x21 sub-matrix at the center of filter matrix. Next, through FFT the frequency domain function of the image is obtained. Then frequency Domain filtering is done through element by element multiplication of FFT matrix with the FFT matrix of the image. Next the product frequency domain FFT matrix is given for IFFT block. Then the output is normalized. Multiply the normalized MSR output signal of each channel with their individual color restoration matrix. Finally add offset and multiply with the gain.

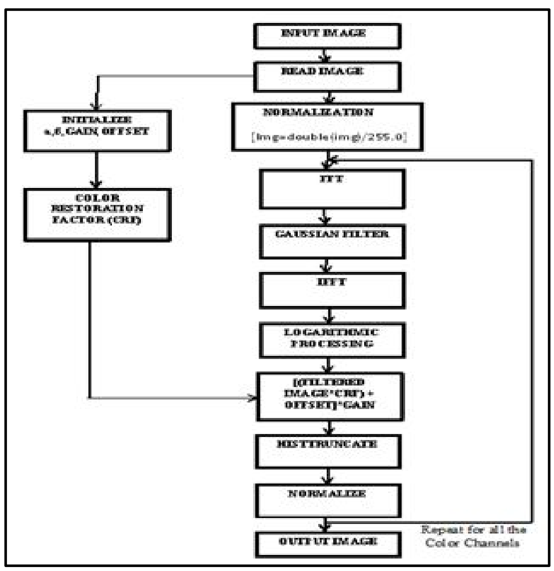
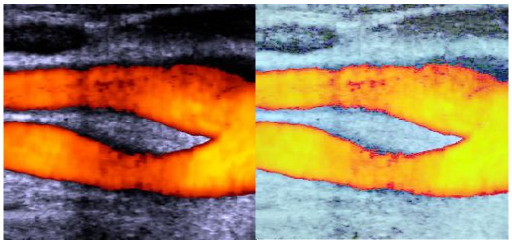



*Figure 12: Flowchart for MSRCR*

- Step 1: Input image and read the image. Image read as array of values.
- Step 2: Initialize α =125 (range 0-255), β = 6.5 (range 4.5-8.5), gain = 0.35 (range 0.01-0.8) and offset = 0.65 (range 0.15-1.15).
- Step 3: Obtain Color Restoration Factor
- $CRF_{red} = [\log(\propto * I_r) - \log(I_{grey})] * \beta$
- $CRF_{green} = [\log(\propto * I_g) - \log(I_{grey})] * \beta$
- $CRF_{blue} = [\log(\propto * I_b) - \log(I_{grey})] * \beta$
- Step 4: Normalization done so that image pixel values are converted to a range of 0-1.

- Step 5: Fast Fourier Transform is obtained
- Step 6: Gaussian filtering is done along with particular surround function constant ie; 15, 80 & 200
- Step 7: Inverse fourier transform is taken.
- Step 8: Logarithmic processing is done so that low intensity pixel values will also get enhanced.
- Step 9: [(Filtered image * CRF) + offset] * gain
- Step 10: Histtruncate function will truncate a specified percentage of lower and upper ends of the image histogram. Clip values are 0.6 each.
- Step 11: Normalize pixel values so that the minimum value of the array is mapped to 0 and maximum to 255.
- Step 12:Step 5 to Step 11 is repeated for red green and blue color channel.
- Step 13: Enhanced output image is obtained.



(a) (b)

*Figure 13: Color Doppler (a)original image (b)output image*

**4.Conclusion**

The Retinex is one kind of image enhancement theory and it established at the scientific experiments and the scientific analysis. Retinex has shown itself to be a very versatile automatic method and can simultaneously provide sharpening, color constancy, dynamic range compression and color rendition. In this paper, we studied the high resolution image enhancement algorithm based on Retinex theory. The proposed image enhancement method constitutes a successful enhancement of medical images. The medical images are collected and the result demonstrates that the algorithm can do a better enhancement to those images. The developed algorithm provides necessary information and helps medical practitioners to perform diagnosis better.

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