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Study and Analysis of Various Noise Models and Efficient Noise Removal on Digital Images

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Abstract:

In image processing, noise reduction and restoration of image is expected to improve the qualitative inspection of an image and the performance criteria of quantitative image analysis techniques Digital image is inclined to a variety of noise which affects the quality of image. The main purpose of de-noising the image is to restore the detail of original image as much as possible. The criteria of the noise removal problem depends on the noise type by which the image is corrupting .In the field of reducing the image noise several type of linear and nonlinear filtering techniques have been proposed. Different approaches for reduction of noise and image enhancement have been considered, each of which has their own limitation and advantages.

Keywords:
Wavelet transform, Median filter, Salt and Pepper noise, impulse noise, TVL1 noise, PSNR and RMSE.

I.INTRODUCTION:

Image restoration is preliminary track in image processing in current time. Image noising (distortion) is one of the well-known and a common issue in Image processing system. Image denoising operation is often used to denoise the degraded image. Image noising is generally seen due to various types of noise, for example Gaussian noise, Impulsive noise, Poisson noise and Speckle noise etc. These are fundamental noise types in case of digital images. Impulsive noise is completely removed by conventional median filter rather than other noise types. Impulsive noise is classified into Salt and Pepper noise and random valued noise.

In this paper, initially we use salt and pepper noise because it is the most common and seen in general image processing operations. Noise is introduced in images during image acquisition or transmission or recording. This phenomenon may happen due to Electronic or photometric sources. If the image formation, transmission and reception processes in Electronic or photometric sources are imperfect, they produce blurred image.

Image formation processes such as spreading of focal length, non-stationary camera placement cause bandwidth reduction in an image. Salt and pepper noise are generally caused by camera sensors, misaligned lenses and weak length of focal etc., That is why careful study of salt and pepper noise is essential which leads to proper selection of noise model for image denoising operations. Day by day the demand of the quality images is increasing. That is why the proposed scheme is to try to maintain the quality of visual perception of an image and also try to remove most of the noisy part in the degraded images.

Non-linear techniques have been proposed and used successfully for image denoising. However, traditional linear filtering does not perform well in case of non-linear operation of impulsive noise during image formation and transmission. An image signal has structural constraints, for examples lines, junctions, edges, corners and other fine details.

II. WAVELET TRANFORM:

Fourier Transform has been used for time frequency analysis. Fourier Transform has certain limitations and those are overcome by Wavelet transform, so wavelet transform is good replacement for Fourier transform. The wavelet transform is able to analyze the time frequency content of an image. It provides multi resolution operations. Wavelet transform works on dilation and translation properties that give a group of template functions. Unlike Fourier transform, wavelet transform can be chosen with more freedom without the need of using sine-cosine pairs

(A) Discrete Wavelet Transform (DWT):

DWT is used to find the approximation and detailed coefficients of a discrete signal. DWT represents the time frequency analysis of discrete signal. Spectrum analysis and spectral behavior of the signal in time

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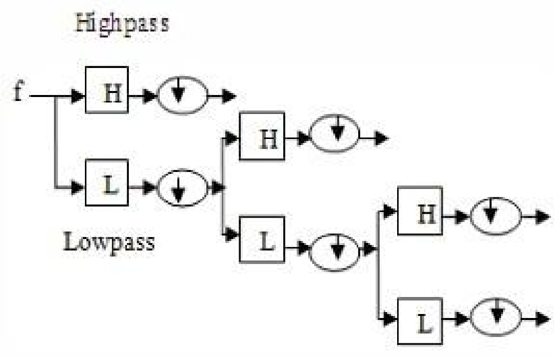
is essential and that is analyzed by DWT. In wavelet decomposition, signal breaks it into two classes; low pass and high pass. These classes are separately used to carry information of original signal as shown in Fig. 1.



III. MEDIAN FILTER:

Median filter (Non-linear filter) works on medial pixel value of its surrounding neighbors instead of mean filter (linear filter). To preserve the smoothness in a resultant image median filter is most prominent choice. A median filter operates on pixel based noise reduction approach under structural constraints. In order to retain the smoothness and edges median filters are best choice among the other non-linear filters. In the context of Order statistics theory, the intensity value of an image is critical choice in deciding the ranking of the neighboring pixels. To overcome the above criteria value of noisy pixel is replaced by the median value of surrounding pixel values.

IV. PROPOSED METHOD:

Here an integration of wavelet transform and median filter. This integrated approach is used for removal of salt and pepper noise from an image.

Basically here a comparison of three most popular and elegant noise models, impulse model, proposed salt & pepper noise model and TVL1 noise. These three noise models are compared on the basis of iterative noise density in the proposed method. We exploit the powerful integration of wavelet transform and median filtering approach. These two schemes are jointly used to remove salt and pepper noise in an image. This combined approach overcomes the limitations of each of them. Multilevel wavelet decomposition is used in this paper. The multilevel wavelet decomposition is used to arrange coefficients in a manner that enables time-frequency analysis. These coefficients are improved via wavelet in order to achieve the smoothness. Smoothness is generally seen in the low pass region where as edges are seen in the high pass region. Here there is an exploitation of iterative noise density scheme in salt and pepper noise model. The filtering window is set of 3x3 pixels. Of course 3x3 filtering window itself cannot be justified under restriction of the expansion of the filter size. Result needs the adaptation in a given filter according to optimum choice.

To preserve smoothness and edges of an image we need wavelets operation in much more depth for which wavelet is reasonable choice. That is why an integration of wavelet based iterative noise density and Median filter is the best approach for salt and pepper noise. In this paper an image is corrupted by salt and pepper noise. That is why to estimate the noise densities of salt and pepper noise is essential and successfully measured in our algorithm.

First wavelet transform decomposed the noisy image Z (j, k) in the form of approximate and detail components. In the proposed method, the detail components are set to zero. Further the approximate pat using the median filter.

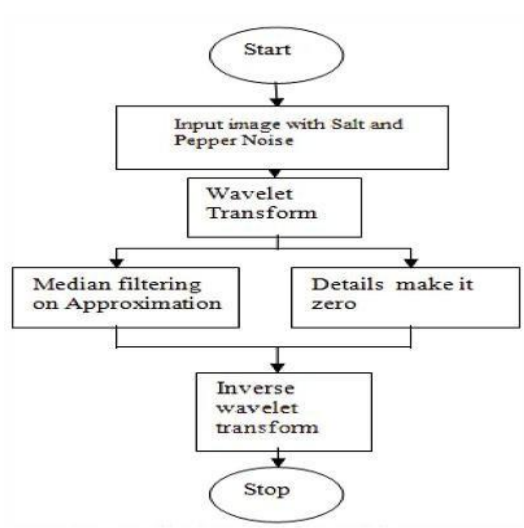
The following equations represent the proposed method.

$$Z(j,k) = D[j(j,k)] + I(j,k)$$

Where $f(j,k)$ is original image, $I(j,k)$ is Noise signal, $Z(j,k)$ is degraded image and D is degrading function.

$I(j,k) \in A \equiv \{1,......E\}X\{1,.......F\}$ is 256X256 resize gray level image at pixel location (j, k)

Where $\{1,......E\}$ and $\{1,.......F\}$ are the rows and columns of $I(j,k)$ respectively.



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$$Z(j,k)=\begin{cases}0\\1\end{cases}$$

Noisy image $Z(j,k)$ probably identified in terms of noise intensities. For a good quality image needs the following noise intensities values 0 represents black (Pepper) and 1 represents white (Salt) [24].

The DWT of degraded image $Z(j,k)$ is

$$w(j,k)=W(j,k)Z(j,k)$$

This implies the approximation and details signals

$$w(j,k)=\{A_{2^j}^{\prime}f, D_{2^j}^{1}f, D_{2^j}^{2}f, D_{2^j}^{3}f\}$$

Whereas $A_{2^j}^{\prime}f$ is the approximation corresponds to Low frequencies and $D_{2^j}^{1}f, D_{2^j}^{2}f \ and \ D_{2^j}^{3}f$ are details of the wavelet $w(j,k)$ set to zero.

$$D_{2^j}^{1}f=0,\ D_{2^j}^{2}f=0 \text{ and } D_{2^j}^{3}f=0$$

Since image denoising schemes based on neighbor pixels. Original pixels of an image are caused by noise. In median approach, frst identified those noisy pixels and comparing each of pixels by their neighbors. Noisy pixel secures some different value. Therefore this value is replaced by median value of its surrounding neighbor pixels

Apply median filtering upon the approximation coefficients of wavelet transform and estimate the noise variance ($\hat{v}$).

$$\hat{v}=MED\{A_{2^j,1}^{\prime}, A_{2^j,2}^{\prime}, A_{2^j,3}^{\prime}\ldots\ldots, A_{2^j,N}^{\prime}\}$$

Taking Inverse Discrete Wavelet Transform (IDWT)

$$\hat{f}(j,k)=W^{T}w(j,k)$$

Our objective is to obtain the denoised image $\hat{f}(j,k)$ is close to original image $f(j,k)$ as possible.

Error is $e(j,k)=\hat{f}(j,k)-f(j,k)$

That is why Mean square error is

$$MSE=\frac{1}{PQ}\sum_{p=0}^{P-1}\sum_{q=0}^{Q-1}[f(j,k)-\hat{f}(j,k)]^2$$

The Peak signal to noise ratio is given by

$$PSNR=20\log_{10}\frac{255^2 PQ}{\sum_{p=0}^{P-1}\sum_{q=0}^{Q-1}[f(j,k)-\hat{f}(j,k)]^2}dB$$

V. DIFFERENT NOISE TYPES IN IMAGES:

Noise is introduced in the image at the time of image acquisition or transmission. Different factors may be responsible for introduction of noise in the image. The number of pixels corrupted in the image will decide the quantification of the noise. The principal sources of noise in the digital image are:

a) The imaging sensor may be affected by environmental conditions during image acquisition.

b) Insufficient Light levels and sensor temperature may introduce the noise in the image.

c) Interference in the transmission channel may also corrupt the image.

d) If dust particles are present on the scanner screen, they can also introduce noise in the image.

Noise is the undesirable effects produced in the image. During image acquisition or transmission, several factors are responsible for introducing noise in the image. Depending on the type of disturbance, the noise can affect the image to different extent. Generally our focus is to remove certain kind of noise. So we identify certain kind of noise and apply different algorithms to remove the noise. Image noises can be classified as Salt & pepper noise, Impulse noise and TVL1 noise.

(A) IMPULSE NOISE:

Impulse noise corruption is very common in digital images. Impulse noise is always independent and uncorrelated to the image pixels and is randomly distributed over the image. Hence unlike Gaussian noise, for an impulse noise corrupted image all the image pixels are not noisy, a number of image pixels will be noisy and the rest of pixels will be noise free. There are different types of impulse noise namely salt and pepper type of noise and random valued impulse noise. In salt and pepper type of noise the noisy pixels takes either salt value (gray level -225) or pepper value (grey level -0) and it appears as black and white spots on the images. If p is the total noise density then salt noise and pepper noise will have a noise density of p/2.

(B) TOTAL VARIATION NOISE:

Total variation based methods are widely applied for image enhancement and particularly for de-noising. The majority of these is designed for a specific noise model. The alternative total variation based approach proposed here can deal with multiple noise models via two-pass iterative algorithm basing on total variation. The first pass is designed for draft denoising and to detect noise region. The second pass restores the noise region by total variation based inpainting. Experiments on Salt & Pepper and Impulse noise models demonstrate the effectiveness of the proposed method.

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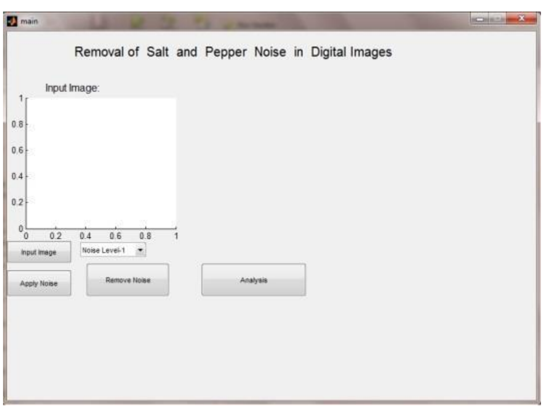
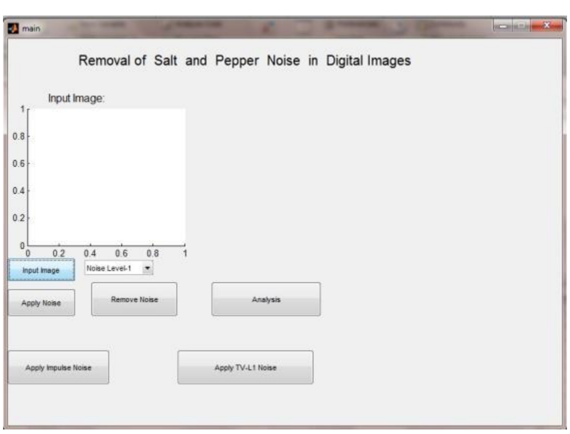
The alternating minimization algorithm recently proposed in to the case of recovering blurry multichannel (color) images corrupted by impulsive rather than Gaussian noise. The algorithm minimizes the sum of a multichannel extension of total variation (TV), either isotropic or anisotropic, and a data fidelity term measured in the L1-norm. We derive the algorithm by applying the well-known quadratic penalty function technique and prove attractive convergence properties including finite convergence for some variables and global q-linear convergence. Under periodic boundary conditions, the main computational requirements of the algorithm are fast Fourier transforms and a low-complexity Gaussian elimination procedure. Numerical results on images with different blurs and impulsive noise are presented to demonstrate the efficiency of the algorithm. In addition, it is numerically compared to an algorithm recently proposed in that uses a linear program and an interior point method for recovering gray scale images. Total variation denoising (TVD) is an approach for noise reduction developed so as to preserve sharp edges in the underlying signal.

V. SIMULATION RESULTS:

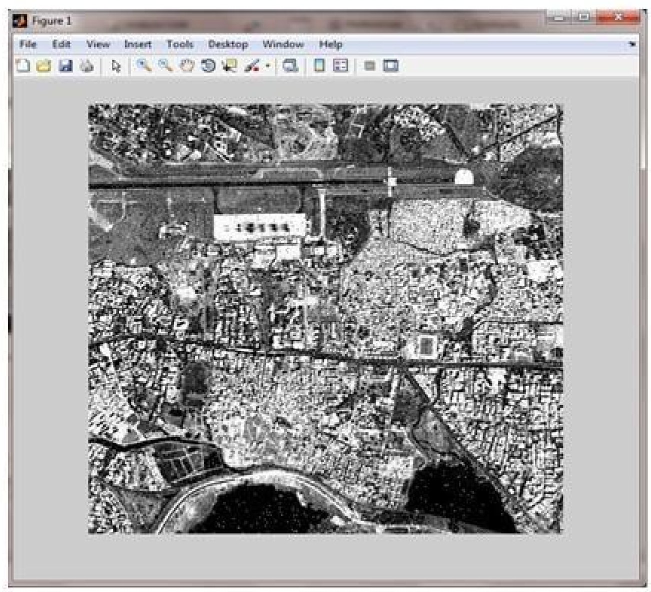
(A) GUI Window:



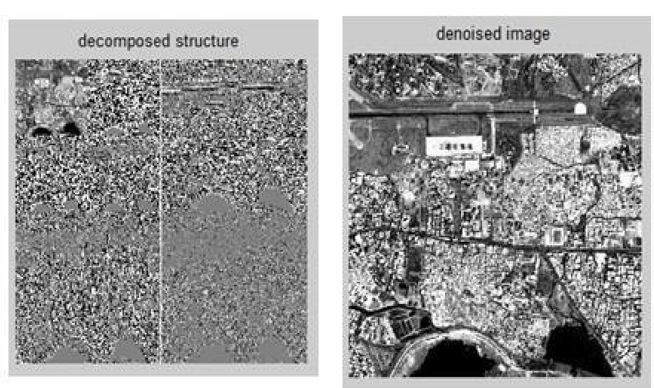
(B) GUI window of noise models:



Selecting Noise Level-1 for the input image



Application of Noise to the selected input image



Decomposed structure and Denoised image

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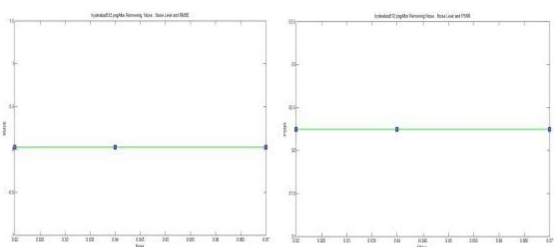
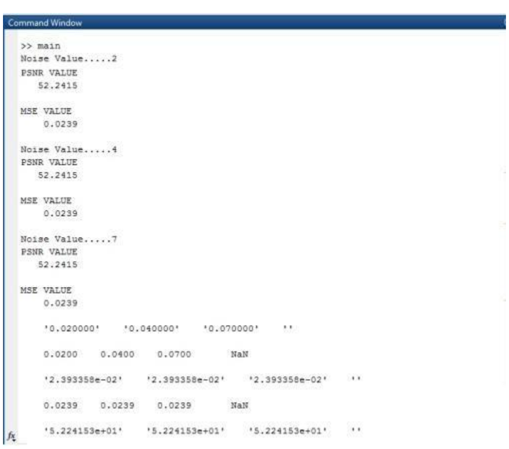
Image obtained after noise removal

Similarly, by randomly selecting the Noise levels present in the GUI window we can get the images applied with chosen noise levels thereby removing the noise we shall get the denoised image as a resultant output. As per the work done in the paper the noise levels of Level 2, 4 & 7 are selected and tested on the image and accordingly the resultant RMSE and PSNR graph is simulated for the corresponding values.

For better understanding the graphical results are displayed in the command window alternatively.

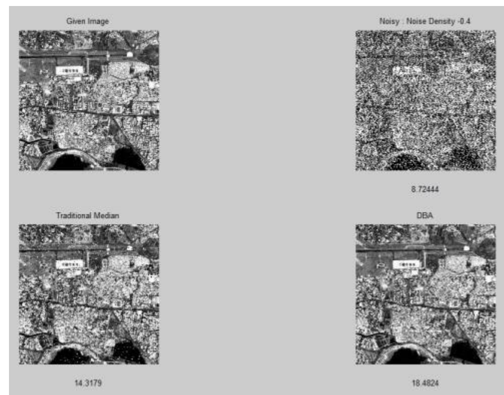


RMSE & PSNR Graph of Noise Level



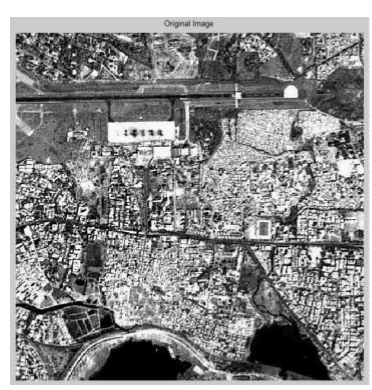
RMSE & PSNR values displayed in the command window for corresponding noise levels

Application of impulse noise to the input image

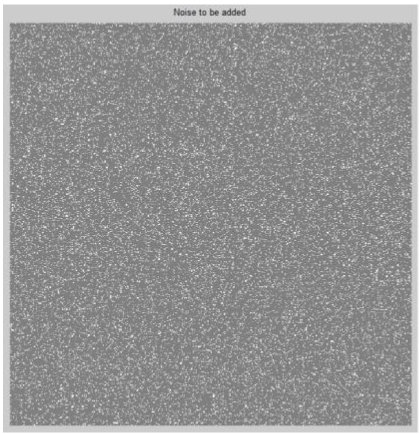


Denoising after applying noise density of 0.4

Application of TVL1 noise to the input image



Original image



Noise to be added to the original image

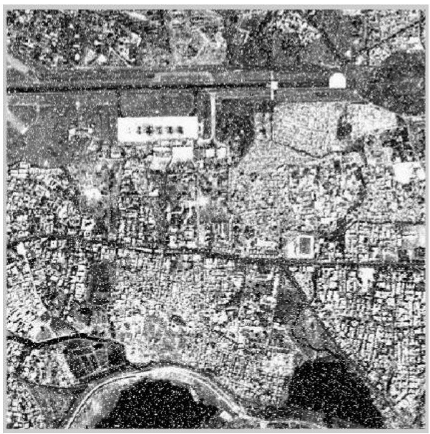


Image obtained after applying noise

Image obtained after noise removal

VI.CONCLUSION:

In this paper, it is shown that Salt and Pepper noise model perform well using wavelet transform and median filter approach. Hence it is observed that the proposed method simply produces better results over the nearly constant result of traditional noise models. The increase in the PSNR value and down fall in the RMSE value against the noise makes the result better. In the proposed method, median filtering minimized Salt and Pepper noise more accurately as compared to other noise models. Different approaches for reduction of noise and image enhancement have been considered, each of which has their own limitation and advantages.

REFERENCES:

[1] A. Bovick, "Handbook of Image and Video Processing," Acedemic press New York, 2000.

[2] R. C. Gonzalez and R. E. Woods, "Digital Image Processing," second ed., Prentice Hall, Englewood, Englewood, Cliffs, NJ, 2002.

[3] J. Patil, and S. Jadhav "A Comparative Study of Image Denoising Techniques," Interational Joural of Innovative Research in Science, Engineering and Technology, vol. 2, issue 3, March 2013.

[4] S Mallet "A Wavelet Tour of Signal Processing," Academic Press, New York, 1998.

[5] V. Zlokolica, A. Pizurica and w. Philips, "Wavelet-Domain Video Denoising Based on Reliability Measures" Circuits and Systems for Video Technology, IEEE Transactions, vol. 16 , no. 8, pp. 993-1007, August, 2006.

[6] S. M. M. Rahman and M. K. Hasan "Wavelet-domain iterative center Science, vol. 83, no. 3, pp.603-61O, Feb. 2003.

[7] David L. Donoho and lain M. Johnstone, "Ideal Spatial Adaption Via Wavelet Shtikage," Biometrika" vol. 3, pp.I92-206, Mar. 1994.5 Sep., 1994

[8] N. Debande, Y. Souissi, M. A. E. Aabid, S. Guilley and J. L. Danger, "Wavelet transform based pre-processing for side channel analysis," 45th Annual IEEEACM Interational Symposium on Microarchitecture Workshops, 1-5 Dec. 2012.

[9] R. Yang, L. Yin, M. Gabbouji, J. Astola, and Y. Neuvo "Optimal Weighted Median Filters Under Structural Constraints," IEEE Transactions on Signal Processing, vol. 43, no. 3, pp. 591-604 March 1995.

[10] S. Salivahanan, A. Vallavaraj, and C. Gnanapriya "Digital Signal Processing," Tata Mcgraw-Hill, vol. 23, NewDelhi, 2008.

[11] T. Chhabra, G. Dua and T. Malhotra "Comparative Analysis of Denoising Methods in CT lmages" Interational Joural of Emerging Trends ill Electrical and Electronics, vol. 3, issue. 2, May-20B.

[12] S. Tong, G. Moncef and N. Yrj6 "Analysis of two-dimensional center weighted Median flter," Multidimensional Systems and Signal Processing, vol. 6, pp. 159-172, 01 April 1995.

[13] L. Rudin, S. Osher, and E. Fatemi, "Nonlinear total variation based noise removal algorithms", Phys. D, 60 (1992), pp. 259–268.

[14] T. Le, R. Chartrand, T. Asaki. "A Variational Approach to Constructing Images Corrupted by Poisson Noise," Journal of Mathematical Imaging and Vision, vol. 27(3), pp. 257–263, 2007.

[15] Aubert, G., Aujol, J.F., "A variational approach to remove multiplicative noise". J.on Applied Mathematics 68(4), 925–946 (2008).

[16] A. Chambolle and P.-L. Lions. Image recovery via total variation minimization and related problems.Numerische Mathematik, 76:167{188, 1997.

[17] T. F. Chan, S. Osher, and J. Shen. The digital TV lter and nonlinear denoising. IEEE Trans. ImageProcess., 10(2):231{241, February 2001.

[18] M. Figueiredo, J. Bioucas-Dias, J. P. Oliveira, and R. D. Nowak. On total-variation denoising: Anew majorization-minimization algorithm and an experimental comparison with wavelet denoising. InProc. IEEE Int. Conf. Image Processing, 2006.

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