Image Enhancement Based on Nuclear Fusion using Magnetic Confinement

Indu Sharma, Chandiakditya kumawat**, V.K. Panchal*** and Gaurav Jindal*****

ABSTRACT

The multi scale retina with color healing (MSRCR) has shown itself to be a very flexible automatic image enhancement algorithm that simultaneously presents dynamic range compression, color fidelity, and shade rendition. A range of algorithms exist that provide one or greater of those capabilities, but now not all. In this paper we evaluate the performance of the MSRCR with strategies that are extensively used for photo enhancement. Specifically, we examine the MSRCR with color adjustment methods together with gamma correction and gain/offset utility, histogram modification techniques including histogram equalization and manual histogram adjustment, and other greater powerful strategies consisting of homomorphic filtering and burning and dodging'. The comparison is executed through testing the suite of photo enhancement methods on a fixed of numerous snap shots. We locate that although a number of these techniques paintings well for some of those photographs, best the MSRCR performs universally well at the check set.

Video cameras have these days end up commonplace diagnostic gear in Magnetic Confinement Nuclear Fusion. They offer critical statistics for each the control of the experiments and the physical interpretation of the effects. Since those cameras can produce up to masses of kilo frames according to 2nd and their information content can be very one of a kind, relying on the experimental situations, several new image processing equipment needed to be devised to absolutely make the most these diagnostics. New Structural sample reputation algorithms had been advanced to retrieve the desired facts from the sample recognition algorithms have been advanced to retrieve the desired facts from the huge reservoirs of video frames in a green and reliable way. Specific actual time algorithms, based totally at the computational paradigm of Cellular Nonlinear Networks, were carried out on FPGAs to identify hot spots at the vacuum vessel and consequently to shield JET plasma facing additives. Various devices getting to know gear, mainly Support Vector Machines, were given Hu moments as input to routinely identify plasma instabilities. The method of the optical float has allowed deriving data about the motion of objects in three dimensional spaces even though they were detected by using a unmarried camera. A new anomaly detector based on a unique interpretation of external guide vectors is being examined with very nice outcomes. Many of the more innovative solutions are primarily based on pretty popular strategies and are therefore anticipated to be applicable additionally in different fields of research.

Keywords: *Real time image processing; Infrared Thermography (IR); SVM Regression; multiscale retinex with color restoration (MSRCR); Non-linear Point Transforms; Histogram Equalization; Point operations; Homomorphic filtering; Manual Burning and Dodging.*

1.0 Introduction

**Corresponding author*; *Research Scholar, Department of Computer Science, Mewar University, Chittorgarh, Rajasthan, India. (Email: Indu19852000@rediffmail.com)*

***Professor, Department of Computer Science, Mewar University, Chittorgarh, Rajasthan, India. (Email: chandikaditya@gmail.com)*

****Ex-Director & Scientist, Department of IT, Defence Terrain Research Lab DRDO, Delhi, India. (Email: vkpans@gmail.com)*

*****Associate Professor, Department of "Management & Commerce, TIPS, Dwarka, Delhi, India. (Email: gauravjindal05@gmail.com)*

The Multiscale Retinex1 (MSR) is a generalization of the single-scale retinex2 4 (SSR), which, in turn, is based upon the ultimate model of Land's middle/surround retinex5. The cutting-edge model of the MSR combines the retinex dynamic range compression and shade constancy with a shade 'recovery' filter that provides notable colour rendition6 eight. This version of the MSR is known as the Multiscale Retinex with Color Restoration (MSRCR). The MSRCR has been examined with a totally big suite of snap shots and has consistently tested to be higher than any conventional photograph enhancement approach.

Transforms consisting of the logarithmic remodel or the 'square-root' transform; and global transforms along with histogram equalization [9], homomorphic filtering [10], and guide 'burning and dodging.'

FOR human beings visible notion constitutes the primary supply of statistics. The part of the Brain devoted to photograph processing is considerably large than the only of all the other senses. On the alternative hand, only these days, with the appearance of cameras and computers, it has come to be smooth to seize and store pics on outside helps and no longer in reality on character recollections. Whereas as much as the end of the 19 century most effective artists and illustrators had the privilege of producing images, normally on some form of paper or canvass, these days it has become viable for everyone now not handiest to file man or woman frames but also whole movies. In unique digital video cameras have stepped forward and superior so much that they are now discovered in a selection of gadgets, inclusive of cellular telephones, portable virtual assistants, handheld online game consoles and an entire host of different transportable gadgets Video cameras have consequently come to be a tool of comfort, they're being used often to file, create and percentage facts and they are now gambling every day a more position in society, media and way of life [1].

The continuous progress in camera technologies has resulted in commercial products with performance that have become very appealing in many scientific applications. In Magnetic Confinement Nuclear Fusion (MCNF), the number of cameras deployed on the various Experiments has increased steadily in the last decades. Nowadays they have become routine diagnostics with multiple applications, ranging from protection of the first wall to the analysis of plasma instabilities and even the characterization of turbulence.

The foremost challenges to picture processing for MCNF may be grouped into four classes. First of all, the retrieval of the vital data from the repositories of pictures has emerged as pretty a mission. JET database for instance has grown to be quite large, exceeding ninety Terabytes, of which at the least 1/2 is made from motion pictures [2].

The 2d problem is constituted by way of the need to acquire at the least a simple stage of information from the movies in real time. This is complicated through the truth that the typology of objects to be detected could be very wide and that the overall look of the frames (from historical past luminosity to the level of noise) can alternate dramatically from experiment to test.

To overcome this issue parallel computation is required, which has been completed at JET by means of implementing the computational paradigm of Cellular Nonlinear Networks [4] on FPGAs (see section 3). Various system learning strategies have proved additionally to be crucial to properly classify the diverse items acting in the frames especially of the visible cameras (see also phase three).

The third major group of challenges is the want of providing diverse types of statistics for bodily research. An ordinary requirement is the speed of objects, instabilities, pellets or others, captured through the cameras.

Another category of challenges for picture processing in MCNF is connected to photograph interpretation and mainly to the need to become aware of anomalous behavior inside the discharges. A new event detector, based totally on Support Vector Machines (SVM) [6], has been lately advanced at JET and its miles being applied to this hassle of anomaly detection.

2.0 Related Theories and Methods

2.1 State-of-the-art Techniques

In this section we in brief describe the traits of a number of the state-of-the-art techniques maximum typically used for photo enhancement.

2.1.1 Gain/offset correction

One of the maximum common strategies of enhancing a photo is the application of a gain and an offset to stretch the dynamic range of an photo. This is a linear operation and hence has restricted achievement on scenes that embody a miles wider dynamic range than that that may be displayed. In this example, loss of detail occurs due to saturation and clipping in addition to because of negative visibility in the darker regions of the photograph. This process will offer a great visible representation of the authentic scene.

2.1.2 Histogram Equalization

A worldwide approach that works nicely for a wide sort of pictures is histogram equalization. This approach is primarily based at the idea of remapping the histogram of the scene to a histogram that has a close to-uniform probability density function.

This results in reassigning dark regions to brighter values and bright regions to darker values. Histogram equalization works well for scenes which have unimodal or weakly bi-modal histograms (i.e. Very dark, or very brilliant), however now not so nicely for the ones pix with strongly bi modal histograms (i.e. Scenes that comprise very darkish and very vivid regions).

Point operations

Figure 1 indicates a collage of pictures that compares the output of the MSRCR with the factor transforms. As may be seen, the MSRCR furnished the exceptional standard visual nice in every case. The techniques which include histogram equalization perform properly for a huge variety of scenes; however they also fail for a large set. The MSRCR outperforms the alternative techniques universally.

Homomorphic filtering

Figure 2 suggests an assessment of the MSRCR with homomorphic filtering. The homomorphic clear out constantly furnished splendid dynamic variety compression however is lacking in very last coloration rendition. The output of the homomorphic filter out in impact appears extraordinarily hazy as compared with the output of the MSRCR although the dynamic range compression of the 2 methods seems to be similar.

Manual Burning and Dodging

Figure three shows a comparison of the MSRCR with the consequences obtained via the use of manual burning and dodging. The manually processed photo indicates an improvement over the unique as far because the data and detail within the darkish regions is worried however it lacks the vividness and coloration saturation that the MSRCR picture retains and even enhances.

There is obvious streaking from the very local operation of the tool stroke—this could be eliminated but only at the expense of adding considerably to the total processing time.

In the high detail areas where there are sharp differences in reflectance, a tool with size approaching that of a single pixel would be required to bring out all the details. Since the time needed for enhancing a region is roughly in inverse proportion to the size of the tool being used for the processing, this suggests that a very large amount of time would be needed to perform such an

enhancement. On a scene-by-scene basis, the time and effort required for manual manipulation can be reasonable; but the MSRCR produces images that are equivalent or better in quality at a fraction of the time. Because the visual quality of manual burning and dodging is solely limited by the patience and time commitment of the user, the case shown is perhaps typical of the performance achieved by the persistent non-specialist.

REAL TIME IMAGE PROCESSING FOR PROTECTION AND CONTROL INFRARED THERMOGRAPHY FOR PROTECTION OF THE FIRST WALL

The functionality of materials to resist the strength loads precipitated with the aid of thermonuclear plasmas constitutes one of the essential issues at the route to a commercially viable nuclear fusion reactor. Therefore a good sized a part of the clinical and technological efforts on current Tokomaks is devoted to figuring out the exceptional combination of materials able to withstanding the energy and particle loads of high temperature plasmas without spoiling their performance. This hassle, very sizeable for ITER, is already vital on JET and could represent one of the primary components of each the operation and the scientific activity after the setup of the brand new be wall and the W diverter.

Since excessive temperature plasmas do no longer emit infrared radiation, InfraRed thermography (IR) is a very useful device to decide the surface temperature of the plasma dealing with additives. For protection and in preferred for feedback programs, the analysis of the photos ought to be finished in real time.

A series of serial codes, implementing traditional image processing algorithms based on linear algebra, have been developed at JET to identify the hot spots on JET internal surface of the vacuum vessel. Hot spots are regions of the plasma facing components which during a discharge reach temperatures above a certain threshold determined on the basis of machine protection requirements. These traditional algorithms have a very high accuracy and indeed manage to identify the hot regions with practically 100% of success rate. These results have been verified using a database of 11300 frames of JET wide angle IR cameras, which have been all analyzed manually by the experts to determine the hot spots. An example of detection of hot spots is given in the bottom picture of figure 1.

The essential weak spot of this answer is that those serial algorithms present a computational time which relies upon strongly on the contents of the pics. If the variety of pixels to be processed increases so does the computational time. This is illustrated in parent three in which the frames of a video received at some stage in a discharge are analyzed and the computational time required for each one has been calculated. In trendy, for the more common components of the video, the set of rules manages to procedure approximately fifty five frames in keeping with 2d however in some special instances; the desired time can even exceed 9 seconds. This isn't always a very quality scenario because anomalous frames are those that usually imply that something isn't right with the discharge and an urgent selection need to be taken.

To overcome this problem, the Cellular Nonlinear Network (CNN) paradigm has been tested [4]. A CNN usually consists of a bi dimensional array of cells, the evolution of which is modeled by a nonlinear dynamical system and depends on the current state of the cell and on the states of the cells in its neighborhood (usually, a 3x3 sub matrix surrounding the target pixel).

IMAGE PROCESSING OF VISIBLE VIDEOS FOR INSTABILITY IDENTIFICATION

The results of the hot spot detection are quite positive but they have been obtained using frames of JET IR camera. Since high temperature plasmas do not emit in the IR, these images are

relatively clean and in any case much less complex than the ones of the visible, which can present a much more involved phenomenology. The videos detecting radiation in the visible can indeed be much more affected by reflections, emission due to plasma instabilities, emissions due to objects, dusts or flakes, dropping into the plasma etc. Also the general level of background luminosity can vary significantly from one experiment to the other. Therefore even a simple thresholding step cannot be performed in the usual simple way. To obtain the results presented in this sub section, the first extraction of the high luminosity pixels has been performed by first blurring the original image.
This is achieved by replacing the grey level of each pixel with an average over a suitable area surrounding it. Then the blurred image has been subtracted from the original one and then the thresholding is performed on the difference. This is the only robust way identified to perform even this seemingly simple preprocessing step. One important objective of image processing for visible cameras in JET has been the real time identification of Multifaceted Asymmetric Radiation from the Edge (MARFE) events [9]. These instabilities manifest themselves as ribbons of radiations moving up and down the vacuum vessel on the high field side, as shown in figure 4.

To automatically identify these instabilities a classifier based on Support Vector Machines has been trained. More than 4000 frames have been analyzed manually to provide the training and the test sets (60% and 40% of the frames respectively). Since the objects to be detected change position and rotate during the time evolution of the discharge, the simple barycenter's of the ribbon like regions due to the MARFEs are not enough to guarantee a sufficiently high rate of success. To improve the success rate additional information is required, which has been provided as the first two Hu moments. The Hu moments are a combination of central moments of an object in an image, which are practically invariant under rotation, translation and rescaling [10].

3.0 Research Gap

The most research limitation to image processing for Magnetic Confinement using Nuclear Fusion may be classified into four classes. First of all, the retrieval of the vital data from the repositories of pictures has emerged as mission. JET database for instance has grown to be quite large, exceeding ninety Terabytes, of which at the least 1/2 is made from motion pictures [2].

The other group of challenges is the want of providing diverse types of statistics for bodily research. An ordinary requirement is the speed of objects, instabilities, pellets or others, captured through the cameras.

Another category of challenges for image processing in Magnetic Confinement Nuclear Fusion is connected to photograph interpretation and mainly to the need to become aware of anomalous behavior inside the discharges.

4.0 Proposed Work

Fusion diagnostics translate physical behaviors into reproducible structural shapes in the signals.
Studying the phenomena of interest typically requires constructing unique databases to consciousness the records analysis method on the trouble at hand. To this end, particular patterns (i.E. Physical activities) should be discovered inside massive databases.

In general, pattern location has been historically completed in a manual manner. This looking manner turns into intractable in massive databases or under lengthy pulse conditions. The proliferation of diagnostics that use cameras creates an even worse state of affairs with reference to saved statistics and pattern vicinity.

The computerized seek of bodily events in alerts has been recently taken into consideration

for nuclear

Fusion environments. A novel and usual method, Universal Multi-Event Locator (UMEL), lets in the automatic location of events in waveforms and video-films. This technique is primarily based on assist vector machines regression estimations to perceive and discover specific signatures within the alerts which include edges, peaks or textures. These footprints allow the characterization of neighborhood facts both within the time (or space) area or inside the frequency (or spatial frequency/wavenumber) domain or in both.

Simple linear regression consists of minimizing a regularized error function. To obtain sparse solutions in the case of SVM regression, the quadratic error function is replaced by an e-insensitive error function [15]. This defines a region which provides zero error if the difference between the regression estimation and the target value is less than μ.

The SVM regression presents two specific varieties of assist vectors, the ones which are inside the insensitive place and the ones which are outdoor this place. The help vectors which lay outdoor the insensitive place are referred to as outside guide vectors and can be interpreted because the symptom of in particular abrupt modifications within the behavior of the sign. This is the translation proposed in [6] for time collection and carried out to pictures in this paper. The quantity of outside support vectors is indeed an illustration of huge modifications in the arrival of an character frame with appreciate to the common frame in the same video. This is shown graphically in figure 8. The snap shots, which present features significantly distinct from the standard frames, are characterized via an excessive wide variety of outside support vectors. The variety of external support vectors lets in consequently identifying the frames wherein something anomalous is present in the image. The number of external support vectors can be used as an anomaly detector. The advantage of this solution is, among other things, its absolute generality. The approach can be applied to any type of image and is equally useful in analyzing other types of signals, such as time series.

5.0 Results

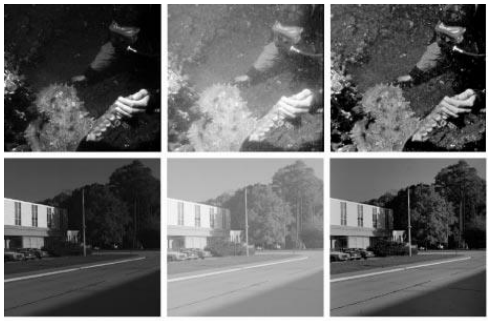
The automatic nature of the process also enables us to use the same set of parameters ‘blindly’ for each and every image that is encountered. Of course, there are a few images for which the MSRCR has sub-par performance. But these are fairly rare and generally relate to defects in the original Image data—such as preferential clipping of a spectral band. We are currently investigating methods to detect such scenes and adaptively adjust the MSRCR to correct for these sub-par performances. adaptively adjust the MSRCR to correct for these sub-par performances.

Figure 1: A comparison of the MSRCR with point operations. Top row: original; second row: histogram equalization; third row: gain/offset; fourth row: gamma non-linearity; bottom row: MSRCR

(a) Original (b) Homomorphic filter (c) MSRCR

Figure 2: A comparison of the MSRCR with images enhanced by homomorphic filtering. The dynamic range compression achieved by

the two methods is comparable, but the MSRCR produces images that possess much better contrast and sharper colors



(a) Original (b) Manual burning and dodging (c) MSRCR

Figure 3: Comparison of the MSRCR with Manual 'Burning-and-Dodging.' The Manually Enhanced zimage was Produced using the

burning and dodging tool provided in Adobe Photoshop 4.0. Circular tools with soft edges were used to modify the color content of
different regions. The total time to produce this enhanced image was 20 minutes. The MSRCR image took 45 seconds on a PentiumPro
200MHz machine.

(a) Original (b) Manual burning and dodging (c) MSRCR

6.0 Conclusion

We have supplied a brief description of the maximum commonly used photograph enhancement strategies and compared their operation with the multiscale retinex with color recovery. We have proven that the MSRCR outperforms those strategies in all cases in terms of dynamic variety compression accomplished, and the rendition of the very last color photograph.

The automatic nature of the manner additionally enables us to use the equal set of parameters 'blindly' for every and each image that is encountered. Of direction, there are some snap shots for which the MSRCR has sub-par overall performance. But these are pretty uncommon and generally relate to defects within the unique Image records—along with preferential clipping of a spectral band. We are presently investigating methods to stumble on such scenes and adaptively modify the MSRCR to correct for these sub-par performances.

New photograph processing tools are indispensable in MCNF to protection operate the subsequent generation of gadgets and to maximize their clinical exploitation. The peculiarities of films of high temperature plasmas require in addition traits. The appropriate advances variety from

photo processing (an photo as enter to the analysis method to offer an picture as output), to photograph analysis (an picture as enter to offer a quantitative dimension as output) and photo interpretation (an photograph as input to reap a high stage of interpretation as output). Particular attention will must be dedicated to the extraction of useful statistics in real time. Further progress could be additionally very applicable inside the area of anomaly detection. From the point view of the hardware, parallel computation and radiation hardness is sincerely some of the foremost issues for the future.

References

A. Bruhn, J. Weickert, C. Schnorr, "Lucas/Kanade meets Horn/Schunck: combining local and global optic flow methods", *Int. J. Comput. Vision*, vol. **61**-3, 211-231, 2005

B. Horn, B. Schunck,–"Determining optical flow", *Artificial Intelligence*, vol. **17**, pp.185 203, 1981.

Chen, Pau & Wang (Eds.) Handbook of pattern recognition & computer vision. World Scientific. pp. 163 - 209. ISBN 981-02-1136-8

D. J. Jobson and G. A. Woodell, "Properties of a center/surround Retinex Part Two: Surround design," *NASA Technical Memorandum #110188*, 1995.

D. J. Jobson, Z. Rahman, and G. A. Woodell, "Properties and performance of a center/surround retinex," *IEEE Trans. on Image Processing: Special Issue on Color Processing*, vol. 6, pp. 451–462, March 1996.

D. J. Jobson, Z. Rahman, and G. A.Woodell, "A multi-scale Retinex for bridging the gap between color images and the human observation of scenes," *IEEE Transactions on Image Processing: Special Issue on Color Processing*, July 1997.

E. Land, "An alternative technique for the computation of the designator in the retinex theory of color vision," *Proc. Nat. Acad. Sci.*, vol. 83, pp. 3078–3080, 1986.
J. Vega, A. Murari and S. González. "A Universal support vector machines based method for automatic event location in waveforms and video-movies: Applications to massive nuclear fusion databases". Rev. Sci. Ins. **81**, 023505 (2010) 11pp.

John C. Russ "The image processing handbook" CRC Press Taylor and Francis Group 5th edition 2007.

L. Chua, T. Roska, "Cellular neural networks and visual computing: Foundations and applications", Cambridge University Press, Cambridge, 2004.

M.Sonka, V.Hlavac, R.Boyle "Image processing, analysis and machine vision" Thomson, London, 2008 Third edition.

O. D. Faugeras, "Digital color image processing within the framwork of a human visual model," *IEEE Transactions on Acoustics, Speech and Signal Processing*, vol. 27, pp. 380–
393, Aug. 1979.

R. C. Gonzalez and P. Wintz, *Digital Image Processing*. Reading, MA: Addison-Wesley, second ed.,

1987.

Richard Layne, Martin Wheatley, "New data storage and retrieval systems for JET data", Fusion Engineering and Design, Volume **60**, Issue 3, June 2002, Pages 333-339, ISSN 0920-3796, DOI: 10.1016/S0920-3796(02)00029-7.

T. G. Stockham, Jr., "Image processing in the context of a visual model," *Proceedings of the IEEE*, vol. 60, no. 7, pp. 828–842, 1972.

Z. Nagy, P. Szolgay, "Configurable Multi-Layer CNN-UM Emulator on FPGA", IEEE Trans. on Circuits and Systems I: Fundamental theory and applications, Vol. **50**, pp. 774-778, 2003