Impact of Bandwidth on IRS-P6 LISS-IV Image using Gaussian Filter: Mysore District of Karnataka, INDIA

Chethan K S and Sinchana G S

PES University, Bangalore, Karnataka, INDIA

Government Engineering College, Kushalnagar, Karnataka, INDIA

Shreevyas H M and Choodarathnakara A L

Government Engineering College, Karwar, Karnataka, INDIA

Government Engineering College, Kushalnagar, Karnataka, INDIA

ABSTRACT

Gaussian filter smoothens digital images during preserving edges, by re-evaluating every pixel. In computing the new pixel value, a window is centered on the pixel of interest with local neighborhood pixels. In this paper, Gaussian filtering technique implemented over IRS-P6 LISS-IV satellite data product to analyze the impact of bandwidth. The recommendation of window is based on the statistical analysis which best enhances the image while preserving the edges. For satellite image with spatial resolution around 1m, window 7X7 for SD = 3, 5x5 for SD = 1.5, 5x5 for SD = 0.75 and 5X5 for SD = 0.375 are recommended. Resulting in blurred image, the largest window 9x9 was recommended to obtain better results.

Keywords : Satellite Data, Gaussian Filter, Enhanced Edges

1. INTRODUCTION

Gaussian filtering [1], [2] has been exhaustively exercised in image processing and computer vision. The noise in the image is smoothed out but the signal gets distorted while suppressing the noise using Gaussian filter. The edge detection using Gaussian filter provides edge position displacement, edges vanishing and phantom edges. To avoid these problems, adaptive Gaussian filtering algorithm was proposed by adapting filter variances for the local variance and noise characteristics [3]. The filter is an extension of k-means nearest neighbor filter for still image noise removal. The rational filter and the alpha trimmed mean filter out-performed in view of visual quality [4].

Zeev Farbman et al. have introduced multi-scale image decomposition as a new method to preserve edges. Authors demonstrated effectiveness of edge preserving decomposition for tone mapping, detail enhancement and other applications [5]. Shutao Li et al. have proposed novel guided filtering to make use of spatial consistency for fusion. They demonstrated computational efficiency and robustness for fusion of multispectral, multifocus, multimodal, and multi-exposure images [6]. Pietro Perona and Jitendra Malik shown that no new maxima will be generated at coarse scales using scales-space diffusion process to encourage intra region smoothing. In this approach region boundaries remain sharp [7].

Mitra Basu extensively reviewed the various features of the filter of choice in the area of edge detection. Author has surveyed several linear and nonlinear Gaussian-based edge detection methods along with the algorithms which suffer from many problems [8]. Choodarathnakara A L and Sinchana G S made an attempt to assess the impact of bandwidth on image quality using Gaussian filter. Authors have considered Mysore city of Karnataka state as study area using LANDSAT-7 ETM+ satellite data for conducting experimentation. They concluded that satellite image with high resolution around 30m, the window 5x5 is recommended for Gaussian filter to enhance the image quality while preserving the edges [9].

This paper is organized as follows: Section II provides the study area and satellite data products used in this study. In section III the proposed methodology was described. In section IV the experimental results are presented to analyze the impact of bandwidth for different standard deviation. Section V presents some concluding remarks.

2. STUDY AREA AND DATA PRODUCTS

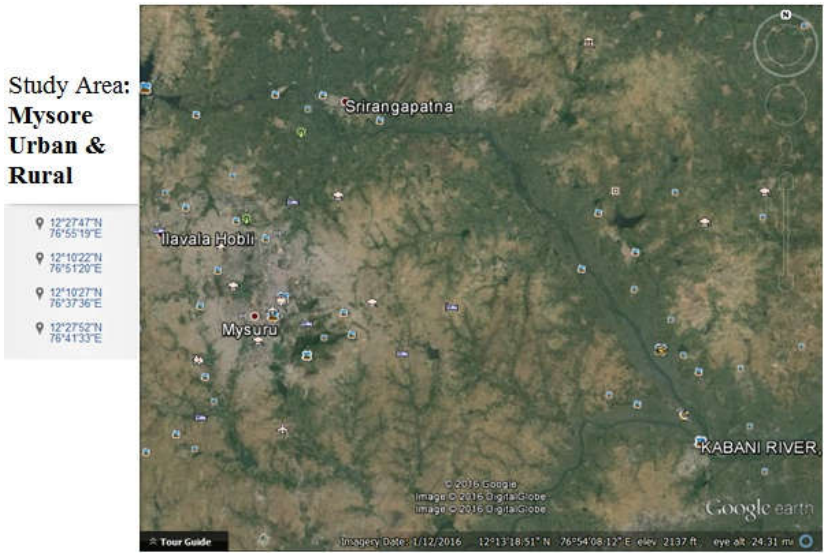

Fig 1: Google Earth Snapshot of the Mysore Urban & Rural Study Area

Mysore study area is located between latitude 11°45' to 12°40'N and longitude 75°57' to 77°15'E spread over an area of 6,854Km^2 and ranked 12th in the state of Karnataka. The temperature in the district varies from 15° C in winters to 35° C in summer. This district positioned on the undulating table land of the Southern Deccan plateau, within the watershed of the Kaveri River. The average rainfall is about 785 mm and the river Kaveri flows through the northern and eastern parts of the district.

3. METHODOLOGY

The methodology adapted as shown in Fig 2 to assess the impact of bandwidth on satellite image using Gaussian filter. During the first phase of the experiment, the data was procured and preprocessed. Gaussian filter was applied with varying window sizes 3x3, 5x5, 7x7, 9x9 for standard deviations 3, 1.5, 0.75, 0.375 respectively. Finally, proper window size was selected based on statistical analysis viz Mean, SD and SNR.

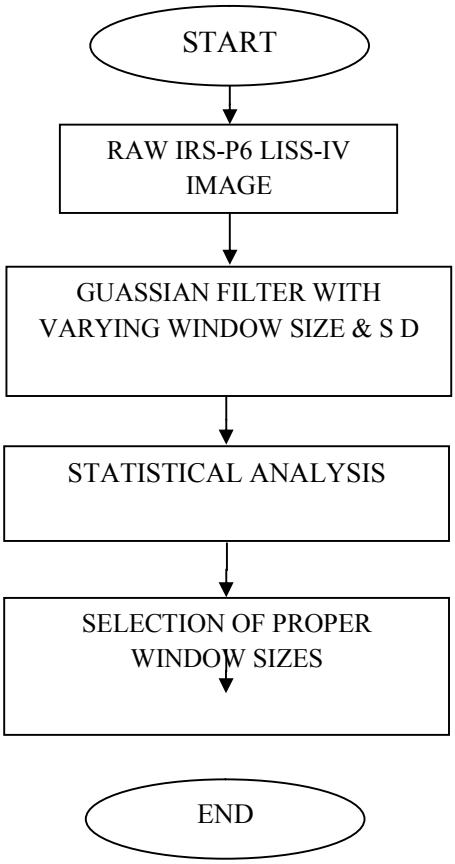

Fig 2: Methodology to Assess the Impact of Bandwidth using Gaussian Filter

4. EXPERIMENTAL RESULTS

Fig 3 depicts the gray scale image of IRS-P6 LISS-IV data considered during this experiment. Fig 4 shows the Gaussian filter response for 3x3 size window with standard deviation 0.375 producing mean value of 37.6458 and standard deviation of 66.9734.

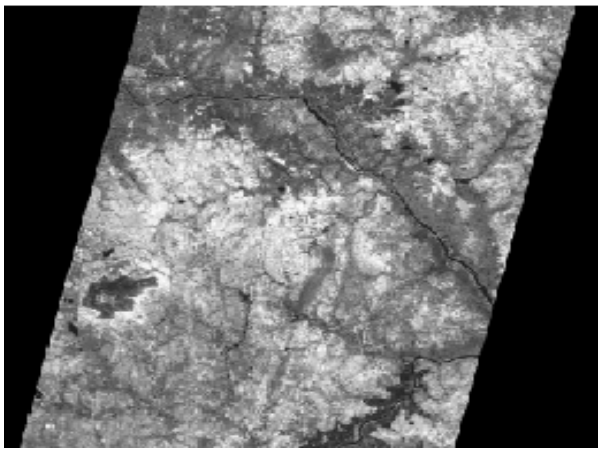

Fig 3: Conversion of IRS Image into Gray Scale

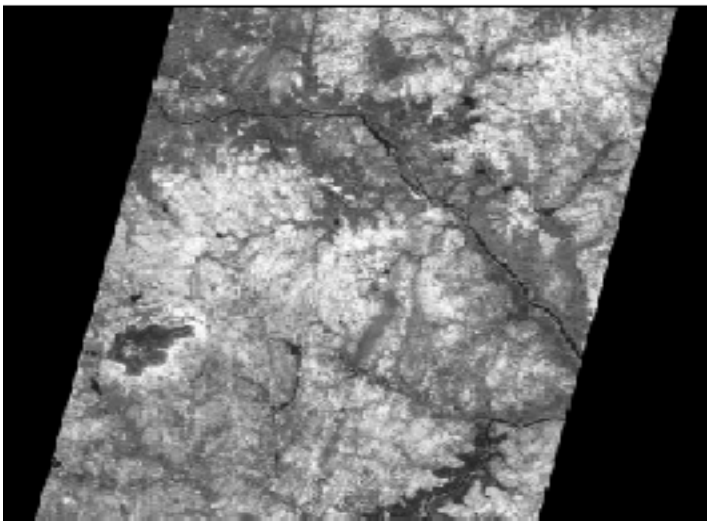

Fig 4: 3x3 Size Window with Standard Deviation 0.375

Fig 5 shows the Gaussian filter response for 3x3 window size with standard deviation 0.75 producing mean value of 38.4209 and standard deviation of 67.7569. Fig 6 shows the Gaussian filter response for 3x3 window size with standard deviation 1.5 producing mean value of 38.3500 and standard deviation of 67.4934. Fig 7 shows the Gaussian filter response for 3x3 window size with standard deviation 3 producing mean value of 38.3241 and standard deviation of 67.4223.

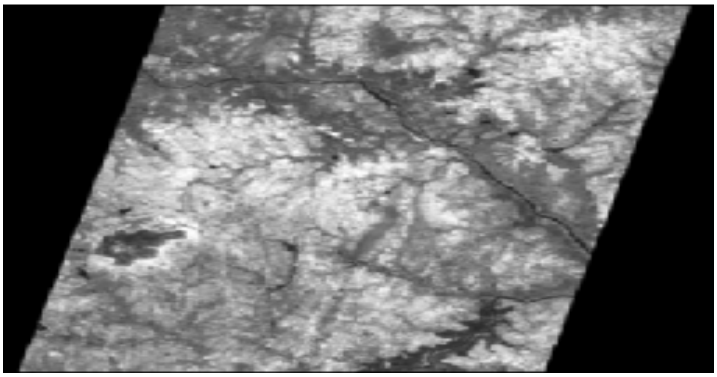

Fig 5: 3x3 Size Window with Standard Deviation 0.75

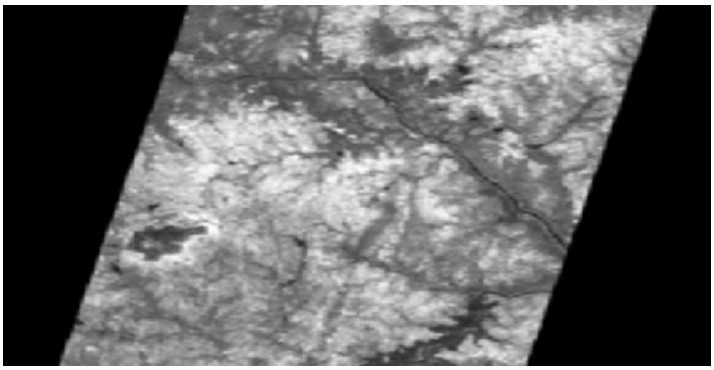

Fig 6: 3x3 Size Window with Standard Deviation 1.5

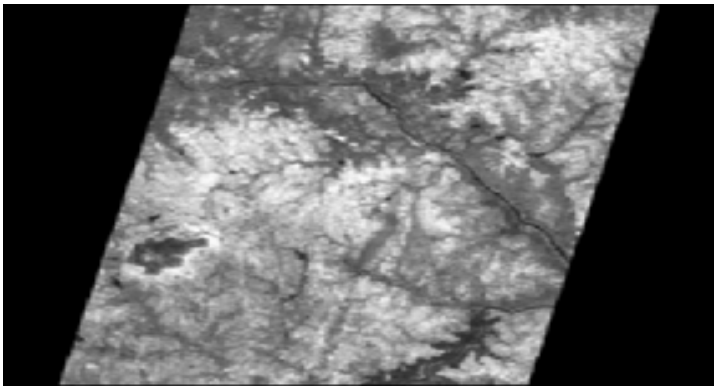

Fig 7: 3x3 Size Window with Standard Deviation 3

Fig 8 shows the Gaussian filter response for 5x5 window size with standard deviation 0.375 producing mean value of 37.6997 and standard deviation of 67.0329. Fig 9 shows the Gaussian filter response for 5x5 window size with standard deviation 0.75 producing mean value of 38.4597 and standard deviation of 67.8292. Fig 10 shows the Gaussian filter response for 5x5 window size with standard deviation 1.5 producing mean value of 38.8617 and standard deviation of 68.1659.

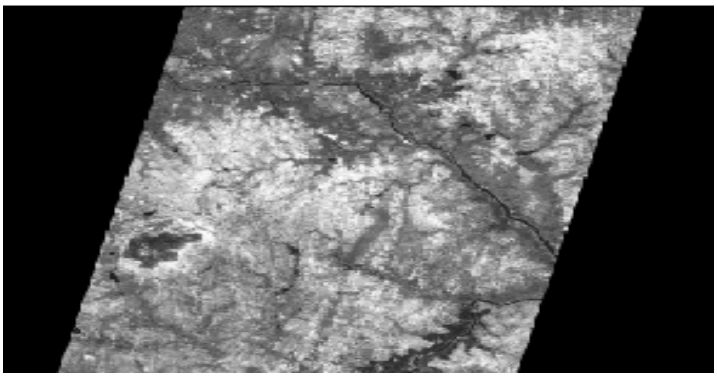

Fig 8: 5x5 Size Window with Standard Deviation 0.375

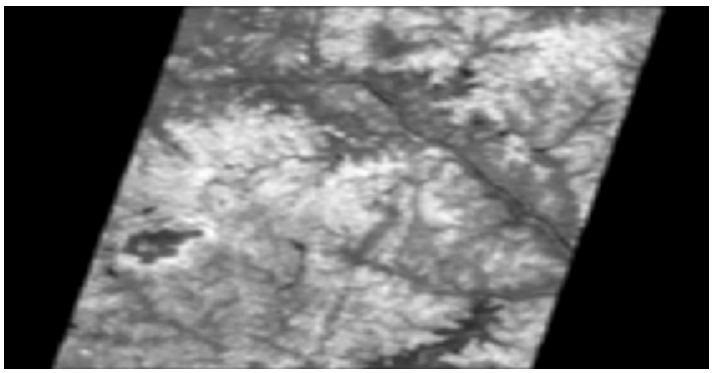

Fig 9: 5x5 Size Window with Standard Deviation 0.75

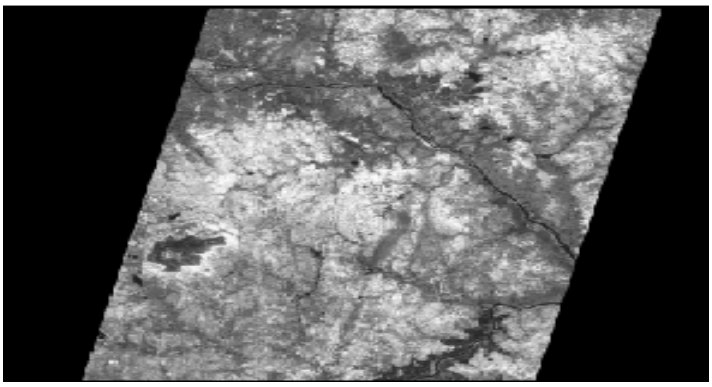

Fig 10: 5x5 Size Window with Standard Deviation 1.5

Fig 11 shows the Gaussian filter response for 5x5 window size with standard deviation 3 producing mean value of 39.0581 and standard deviation of 68.3930. Fig 12 shows the Gaussian filter response for 7x7 window size with standard deviation 0.375 producing mean value of 37.2524 and standard deviation of 66.7243. Fig 13 shows the Gaussian filter response for 7x7 window size with standard deviation 0.75 producing mean value of 38.0833 and standard deviation of 67.5310.

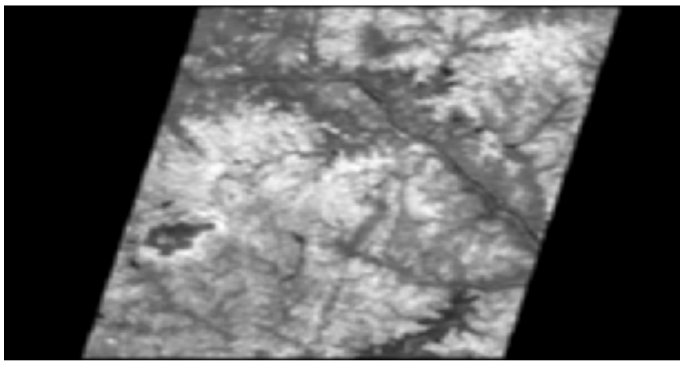

Fig 11: 5x5 Size Window with Standard Deviation 3

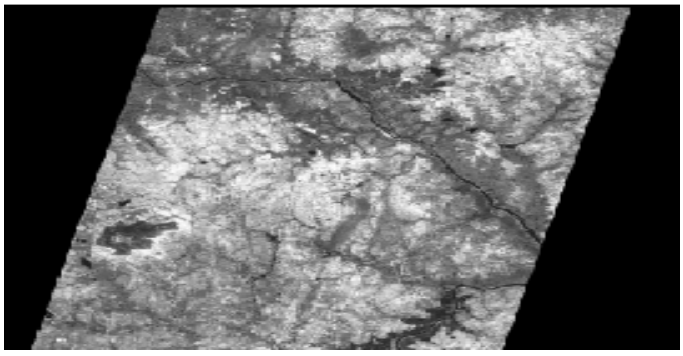

Fig 12: 7x7 Size Window with Standard Deviation 0.375

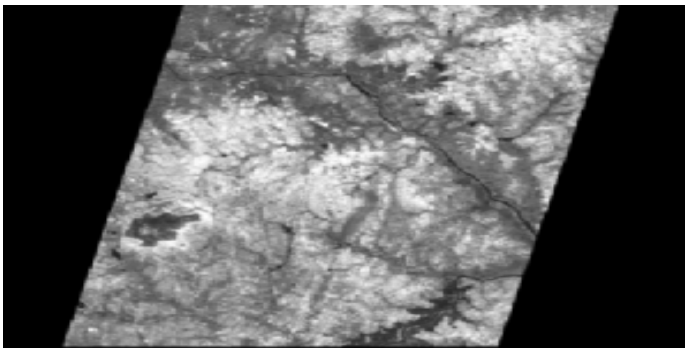

Fig 13: 7x7 Size Window with Standard Deviation 0.75

Fig 14 shows the Gaussian filter response for 7x7 window size with standard deviation 1.5 producing mean value of 38.8324 and standard deviation of 68.3027. Fig 15 shows the Gaussian filter response for 7x7 window size with standard deviation 3 producing mean value of 39.3408 and standard deviation of 68.8971. Fig 16 shows the Gaussian filter response for 9x9 window size with standard deviation 0.375 producing mean value of 36.8982 and standard deviation of 66.5277.

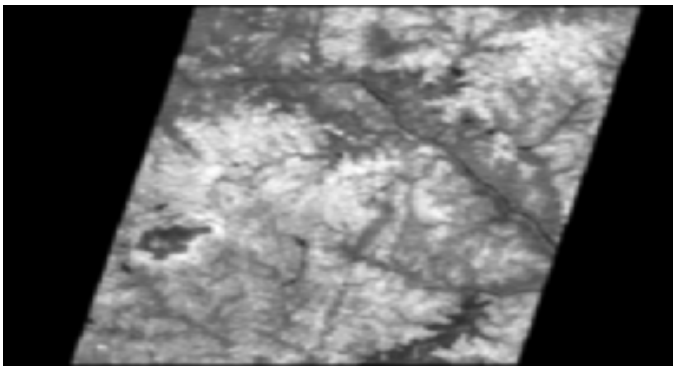

Fig 14: 7x7 Size Window with Standard Deviation 1.5

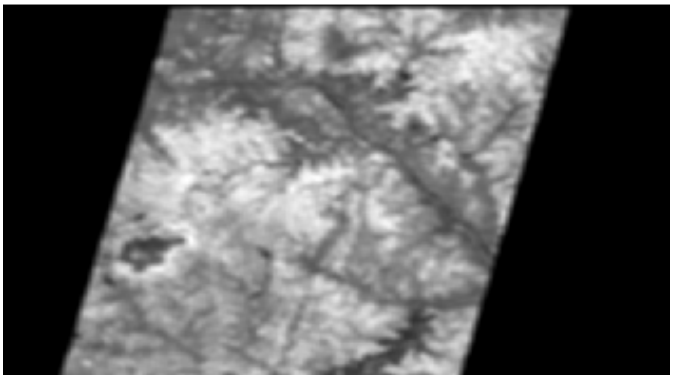

Fig 15: 7x7 Size Window with Standard Deviation 3

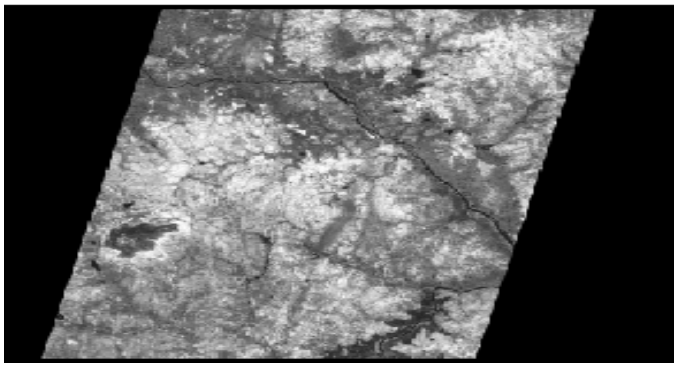

Fig 16: 9x9 Size Window with Standard Deviation 0.375

Fig 17 shows the Gaussian filter response for 9x9 window size with standard deviation 0.75 producing mean value of 37.7851 and standard deviation of 67.4160. Fig 18 shows the Gaussian filter response for 9x9 window size with standard deviation 1.5 producing mean value of 38.6499 and standard deviation of 68.2715. Fig 19 shows the Gaussian filter response for 9x9 window size with standard deviation 3 producing mean value of 39.2994 and standard deviation of 68.8946.

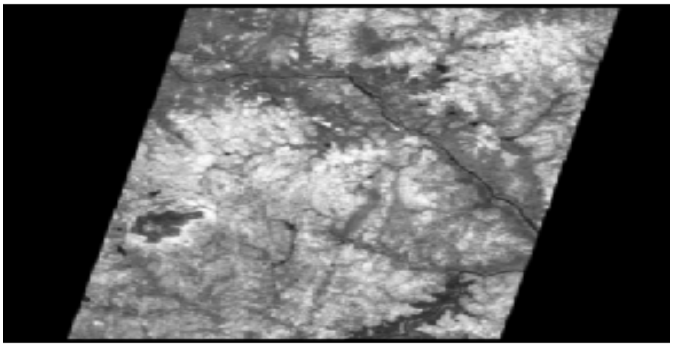

Fig 17: 9x9 Size Window with Standard Deviation 0.75

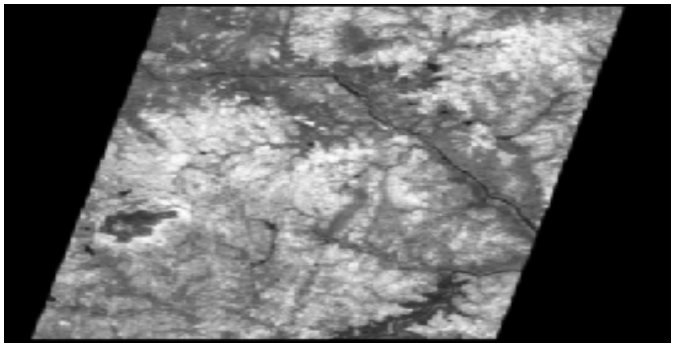

Fig 18: 9x9 Size Window with Standard Deviation 1.5

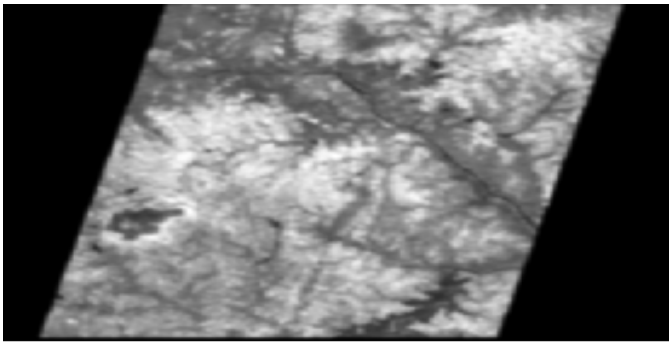

Fig 19: 9x9 Size Window with Standard Deviation 3

Table 1. Statistical Measures of Gaussian Filter for Different Size & SD

Filter Window SD	Window Size	Min	Max	Mean	SD	SNR
		0	225	37.8140	67.0334	0.5641
3	3x3	0	225	38.3241	67.4223	0.5684
3	5x5	0	225	39.0581	68.3930	0.5710
3	7x7	0	225	39.3408	68.8971	0.5710
3	9x9	0	225	39.2994	68.8946	0.5704
1.5	3x3	0	225	38.3500	67.4934	0.5682
1.5	5x5	0	225	38.8617	68.1659	0.5701
1.5	7x7	0	225	38.8324	68.3027	0.5685
1.5	9x9	0	225	38.6499	68.2715	0.5687
0.75	3x3	0	225	38.4209	67.7569	0.5670
0.75	5x5	0	225	38.4597	67.8292	0.5695
0.75	7x7	0	225	38.0833	67.5310	0.5639
0.75	9x9	0	225	37.7851	67.4160	0.5604
0.375	3x3	0	225	37.6458	66.9734	0.5621
0.375	5x5	0	225	37.6997	67.0329	0.5624
0.375	7x7	0	225	37.2524	66.7243	0.5583
0.375	9x9	0	225	36.8982	66.5277	0.5546

Analyzing the statistical values depicted in Table 1, selection of better window can be made for various standard deviations viz. 3, 1.5, 0.75 and 0.375. From Table 1, for window with standard deviation of 3, the filter window size 7x7 was recommended to enhance the image quality while preserving the edges. Similarly, for window with standard deviation of 1.5, the filter window size 5x5 was recommended. For window with standard deviation of 0.75, the filter window size 5x5 was recommended. For window with standard deviation of 0.375, the filter window size 5x5 was recommended.

5. CONCLUSION

The recommendation of window is performed based on the statistics which best improves the quality of image while retaining the edges. The Gaussian filtering approach to preserve the image quality of satellite image with high resolution around 1 m, window size 7X7 for SD = 3, window size 5x5 for SD = 1.5, window size 5x5 for SD = 0.75 and window size 5X5 for SD = 0.375 are recommended. Resulting in blurred images, the largest window size 9x9 was recommended to obtain better results. The Gaussian filtering technique can be implemented further for different satellite data products of interest. The Gaussian filtering technique can be implemented further for more than 9x9 window sizes to analyze the impact of bandwidth as well.

ACKNOWLEDGMENT

Special thanks to Mr. Nasser Mustafa Saleh Abdin for encouragement, guidance and other contributions to this study. All the Landsat 7 ETM+ data used in this work is downloaded from the USGS web (http://glovis.usgs.gov), Special thanks to the group. The authors would like to thank anonymous reviewers for their valuable comments. Also, the authors would like to graciously thank National Remote Sensing Centre (NRSC), Hyderabad, INDIA for providing the data product for the study. Thanks to the Survey of India (SOI) for providing the Topographic Maps for this study and Karnataka State Remote Sensing Application Centre (KSRSAC), Bangalore.

REFERENCES

[1] F. Bergholm, 1987. Edge Focusing, IEEE Trans. Putt. Anal. Mach. Intellig., Vol. PAMI-9, pp. 726-741.

[2] D. Marr and E. Hildreth, 1980. Theory of Edge Detection, Proc. of the Royal Society London B**,** Vol. 207, pp. 187-217.

[3] G. Deng and L. W. Cahill, 1994. An Adaptive Gaussian Filter for Noise Reduction and Edge Detection, IEEE, pp. 1615-1619.

[4] V. Zlokolica, W. Philips and D. Van De Ville, 2002. A New Non-linear Filter for Video Processing, Proc. 3rd IEEE Benelux Signal Processing Symposium, Lenven, Belgium, pp. 21-72.

[5] Zeev Farbman, R. Fattal, D. Lischinski & R. Szeliski, 2008. Edge-preserving Decompositions for Multi-scale Tone and Detail Manipulation, ACM Transactions on Graphics, Vol. 27, No.3, pp. 67:1–67:10.

[6] Shutao Li, Xudong Kang and Jianwen Hu, 2013. Image Fusion with Guided Filtering, IEEE Transaction on Image Processing, Vol. 22, No. 7, pp. 2864-2875.

[7] Pietro Perona and Jitendra Malik, 1990. Scale-Space and Edge Detection using Anisotropic Diffusion, Vol. 12. No.7.

[8] Mitra Basu, Gaussian-Based Edge-Detection Methods—A Survey, Vol. 32, No. 3.

[9] Choodarathnakara A L and Sinchana G S, 2018. Analysis of Image Quality using LANDSAT-7 ETM+ and Gaussian Filter, IJSRCSEIT, Vol. 3, Issue 3, pp. 1296-1304.