**Title Page:**

Additive Noise Removal in Medical Images using Novel Kalman Filter Compared with Gabor Filter for Higher Detection Accuracy

K. Devendra1, Dr G.Kumaran2

K. Devendra1

Research Scholar,

Department of Computer Science and Engineering,

Saveetha School of Engineering,

Saveetha Institute of Medical and Technical Sciences,

Saveetha University, Chennai, Tamil Nadu, India, Pincode: 602105.

[devandarak18@saveetha.com](mailto:devandarak18@saveetha.com)

Dr G. Kumaran2

Research Guide, Corresponding Author,

Department of Computer Science and Engineering,

Saveetha School of Engineering,

Saveetha Institute of Medical and Technical Sciences,

Saveetha University, Chennai, Tamil Nadu, India, Pincode: 602105.

kumarang.[sse@saveetha.com](mailto:nalinim.sse@saveetha.com)

**Keywords**: Medical Images, Novel Kalman Filter, Gabor Filter, Detection Accuracy, Noise Removal ,*Environment*

**ABSTRACT**

**Aim:** The aim of this research work is to enhance the accuracy of noise detection and noise removal in Medical Images using the Novel Kalman Filter for medical findings and the existing popular Gabor Filter**. Materials and Methods:** The proposed models are developed to remove unwanted noise from Medical Images using the Novel Kalman Filter and Gabor filters with sample size of 110 the g-power value of 0.8% The Medical image dataset is used for simulation with the help of the MATLAB image processing toolbox. **Results and Discussion:** The outcome of the proposed Novel Kalman Filter accuracy is improved considerably with the popular Gabor filter (90.93% vs 86.15%). From the accuracy values,The proposed Novel Kalman Filter outperforms the Gabor filter in the field of medical image examining. The p value of 0.005 (p<0.05) indicates that there is statistically significant difference between the two groups. **Conclusion:**The results of the suggested research on novel Kalman filters point to their superiority over the currently used Gabor filter in the field of medical picture assessments and conclusions**.**

.

**Keywords**: Medical Images, Novel Kalman Filter, Gabor Filter, Detection Accuracy, Noise Removal, *Environment*

**INTRODUCTION**

Noise has a part in all digital pictures in the process of picture acquisition, transmission, coding, and the steps of the procedure[(Lekan 2009)](https://paperpile.com/c/6EoUIN/iiij). It is a complex procedure to eliminate the Environment noise from digital pictures, without knowing the basic filtering methods. Those filters are chosen by the analysis of the noise behavior [(Santosh and Hegadi 2019)](https://paperpile.com/c/6EoUIN/EzGQ) The procedures of noise elimination became a much-needed practice in the function of medical imaging for the examination of the anatomical formation and picture processing of MRI pictures. For reporting this problem a lot of de-noising algorithms have been improved such as the Gaussian filter, gabor filter, Wiener Filter, etc [(Vaseghi 1996)](https://paperpile.com/c/6EoUIN/7hd6) Analysis of Noise in the image is a very important part of the procedure in image processing . Environment Images that are in digital format are composed of many types of noises [(Khare 2010)](https://paperpile.com/c/6EoUIN/wjYf). Noise is the outcome of the mistakes in the method of acquisition technique which leads to the pixel value. There are many customs for bringing up a noise into the picture that is based on how it has been formed.

Picture denoising is the process of removing noise from a noisy image in order to restore the original image [(Koundal, Gupta, and Singh, n.d.)](https://paperpile.com/c/6EoUIN/mZWd). Despite this, it can be challenging to distinguish noisy, surface, and edge during the denoising process, and Accuracy Rate the Environment images may lose certain subtlety as a result. Nowadays, it is a major problem to recover important information from noisy images while using clamor expulsion to collect high-quality images. The topic of picture denoising is one that has received a lot of attention. Even yet, it's still challenging and typical work. The main argument for this is that, from a mathematical perspective, picture denoising is an inverse problem, and its solution isn't really novel [(Gunarathne 2013)](https://paperpile.com/c/6EoUIN/Jex8) .Over the past 5 years, more than 300 research papers were accessible in GS (Google Scholar) and more than 150 papers were presented in science direct journals with various filtering concepts Detection Accuracy.

Compared to the results of the other filtering concepts, the Novel Kalman Filter deletes noises from Medical Images with a more accurate rate [Paul, Hitoshi, and Huang 2018)](https://paperpile.com/c/6EoUIN/k8oY+Sidr). The main aim of this research process is to delete the noises from Medical Images using different filtering approaches with a better accuracy value Detection Accuracy. This research work is explained with Gabor and Novel Kalman Filters that are mentioned earlier, used in the real-time imaging technique [(Fourati, Kammoun, and Bouhlel 2005)](https://paperpile.com/c/6EoUIN/2AqI).

**MATERIALS AND METHODS**

This recommended research task was created and developed at the Image Processing Laboratory, Saveetha School of Engineering, SIMATS (Saveetha Institute of Medical and Technical Sciences). This suggested noise removal system contains two kinds of groups Group 1 is taken as a Novel Kalman Filter and Group 2 as Gabor Filter. The Novel Kalman Filter and Gabor filter were evaluated many times by 150 sample sizes. After the gathering of the image database, repetitive and needless portions of the images were uninvolved in the filtering and data-cleaning process. Then, it is associated with the relevant data sets, and the accuracy value of the Novel Kalman Filter (N=10) and Gabor filter(N=10) is calculated and compared.

The Medical Images are gathered and applied in this current research work for the experimental basis. It uses a matlab software tool for making a Filtering system [(Soro, Brereton, and Roe 2018)](https://paperpile.com/c/6EoUIN/dLGg). Among the various software tools, matlab is one of the familiar tools for designing and assessing the outcome of the filters[(Toennies 2012)](https://paperpile.com/c/6EoUIN/IfuU). It contains various library methods and different tools that are used for whole processes associated with the filtering model.

**Novel Kalman Filter**

The uneven variation of brilliance or information of color in images produced by the sensor and circuitry of a scanner or computerized camera is known as picture noise. In addition, picture noise might begin with grainy film and the audible shot noise of a photon finder. Environment Generally speaking, picture noise is seen as an unwanted side effect of picture catch. Despite the fact that they are inaudible and fluctuate, these unwanted vacillations are what is described as "noise" due to a relationship with a disagreeable sound Detection Accuracy. A common cycle used in almost all picture-handling frameworks is filtering the image data. For this reason, channels are utilized. By preserving the image's data, they remove noise from photographs. The filter's decision is influenced by the character.

In honor of Rudolf E. Kalman, a mathematical technique is known as the Novel Kalman Filter. Its rationale is used to identify noise and other errors and to generate numbers that are typically closer to the true upsides of the estimations and their associated determined values. The Novel Kalman Filter is a key component in the development of military and space methodology and has various applications in all fields. It is an algorithm that continuously updates the best detection of the system's current condition using loose optimal information on a direct (or nearly straight) method with Gaussian errors [(IEEE Staff 2018)](https://paperpile.com/c/6EoUIN/XbDV).

**Pseudo code**

input-Coaching and data verification are .

output-A classification of records that have been tested and accuracy.

1. The dataset has been loaded.

2. Randomly selected samples from the dataset were checked out.

3. The goal variables have been set.

4. A classifier that was entirely created using the coaching dataset.

5. Predicted dataset for checking out.

6. Classifier evaluation.

**Gabor Filter**

The Gabor filter is a straight filter, and the sinusoidal wave that drives a degree of 2D Gabor channels tangled by a Gaussian capability is still in the air. The convolution hypothesis states that a Gabor's filter impulse reaction's Fourier Transform (FT) is created by combining a sinusoidal function's FT and a Gaussian capability's FT.

The Gabor filter is made up of several pass-band filters that work within a recurrence range to accept or reject the computations made by the filter. By utilizing a sinusoidal wave to regulate the Gaussian function, Gabor filters can successfully discover edges, surfaces, and Environment component extractions. The orthogonal direction is handled by the Gabor filter.

The benefits of the Kalman-middle filter are: (i) it increments exactness rate ; (ii) it holds picture edge and the time of series low-recurrence correct sign (iii) it is reasonable for exact pictures.

**Pseudo code**

input-Data for from training and testing

output-a class of information testing and correctness

1. a trained dataset was applied.

2. Determine the substantial deviation and infer of the predictor variables.

3. Up until all predictor variables' probabilities have been estimated, the Gauss-Density Equation was used to calculate the probability of each predictor variable.

4. Calculate the likelihood for each class.

5. The greatest probability was obtained.

**STATISTICAL ANALYSIS**

Statistical software tool IBM SPSS with the familiar version 26.0 to identify the value of SD (Standard Deviation), mean deviation data, significance point data and also drawing the graphical representation, etc. The SPSS tool was inclined in the current research process for investigating the concerned database. Image,fog image,blur image,filtering image, real image. Group statistics practice and self-determining sample tests were directed at the investigational outcomes and the graphical format was created for two various graphs with two different kinds of features under the specific experimental phase.

Datasets for training and testing are preferred for the database. The training dataset is recognized by reclaiming the test dataset from the real dataset as long as 400 images data as a whole.

**RESULTS**

A MATLAB software tool is used to examine the data and the accuracy rate is measured among Kalman and Gabor filters. For real-time datasets, the proposed Novel Kalman Filter offers a better accuracy rate than the Gabor filter. The accuracy value of the Novel Kalman Filter 90.93% and the Gabor filter 86.15%.illustrates group statistics based on the real-time dataset of this current research work.

Table 1. Comparison of prediction of accuracy between novel kalman Filters and gabor filter. The novel kalman Filters achieved an accuracy of 90.93% compared to gabor filters having 986.15%. It shows that the novel kalman Filters performed significantly better than gabor filter For Noise Removal in Medical Images. The precision and execution of novel kalman filters were found to be significantly higher than those of gabor filter.This indicates that novel kalman filter is a better choice than gabor filter for this particular dataset and task.

Table 2 Group information displaying the mean, popular deviation, and fashionable error imply values for the two algorithms, novel kalman filter and gabor filter algorithm - with 10 sample sizes. The Performance of novel kalman filter and gabor filter on the Noise Removal in Medical Images is implemented for the given dataset. The results show that the novel kalman filter has a standard deviation of 3.193 and a standard error mean of 1.010. For gabor filter, with a standard deviation of 2.823 and a standard error mean of 0.893.

Table 3 It shows the results of the 2-tailed significance test, which indicates that the difference in accuracy between the two algorithms is statistically insignificant. The 2-tailed significance value of less than 0.019 (p< 0.05) supports the hypothesis that the novel kalman filter is a better choice than gabor filter for this dataset and task

# **DISCUSSION**

The Gabor filter is used in the earlier research work, with a mean rate value of accuracy rate is 86.15%.Novel Kalman Filter is developed, which has a mean accuracy value is91.93%.Noise is because of different sources that remember numerous outer causes for transmission framework and ecological elements which incorporate noise such as Poisson, Gaussian, salt-and-pepper, and speckle noise[(Vaseghi 1996)](https://paperpile.com/c/6EoUIN/7hd6)**.**

The noise-eliminating strategy has turned into a significantly considered clinical imaging application and the most generally utilized filter Wiener filter, Gaussian filter, and gabor filter that provided the best outcome for the respective noises. [(*JJAP* 2007)](https://paperpile.com/c/6EoUIN/R3gr)

proposed a dyadic Gabor filter bank that is joined with the BayesShrink strategy for picture de-noising. In the proposed technique, the noisy picture is disintegrated into various channels in a few levels by a dyadic Gabor filter bank. To recuperate the picture, the noise that is corrupted is eliminated by applying the proposed BayesShrink strategy on the loud Gabor variables[(Kumar and Nachammai 2017)](https://paperpile.com/c/6EoUIN/SmqK).

examined planning the expected condition and the boundary of an adjusted Standard Novel Kalman Filter for sifting or diminishing the noise, unsettling influence, and changing sensor information. The Novel Kalman Filter condition will be hypothetically examined and planned given its part of the formula [(Alfian Ma'arif et al., 2020)](https://www.researchgate.net/publication/342852022_Kalman_Filter_for_Noise_Reducer_on_Sensor_Readings) [(Zhang et al. 2015)](https://paperpile.com/c/6EoUIN/H2HM).

The Gabor filter is one of the familiar filters used in image-handling applications like extracting features, analyzing texture, analyzing patterns, etc[(Sharma et al. 2020)](https://paperpile.com/c/6EoUIN/egDN).To eliminate edges from images [(Toennies 2012; Balamurugan et al. 2021)](https://paperpile.com/c/6EoUIN/IfuU+QbVY), the Gabor filtering method was used. The Gabor filter technique has a hardware accelerator system for image denoising. Hardware systems are also provided for realizing a number of arguments related to the Gabor approach [(Lang, Mousavi, and Fichtinger 2009)](https://paperpile.com/c/6EoUIN/DUrU)**.**

**CONCLUSION**

In the image Environment noise detection and removal, the proposed Novel Kalman Filters outperforms the existing gabor Filter in terms of accuracy (90.93% Vs 86.15%). From the simulation results and statistical analysis, the Novel Kalman Filters is recommended to use in the field of image processing for sensitive information.

**DECLARATIONS**

**Conflicts of Interest**

The author declares no conflicts of interest.

# **Author’s contribution**

Author KD was involved in data collection, data analysis, and manuscript writing. Author GK was involved in conceptualization, data validation, and critical review of the manuscript.

# 

# 

# 

# 

# **Acknowledgement**

The authors would like to express their gratitude towards Saveetha School of Engineering and Saveetha Institute of Medical And Technical Sciences (formerly known as Saveetha University) for providing the necessary infrastructure to carry out this work successfully.

**Funding**

We thank the following organizations for providing financial support that enabled us to complete the research..

1. Sri cuba innovations pvt .ltd.
2. Saveetha University.
3. Saveetha Institute of Medical and Technical Sciences.
4. Saveetha School of Engineering.

**REFERENCES**

[(SPIE 1991 Publications Index: Subject/author Indexes of All SPIE Proceedings and SPIE Press Books Published in 1991 1992)](https://paperpile.com/c/6EoUIN/k8oY)

[(SPIE 1991 Publications Index: Subject/author Indexes of All SPIE Proceedings and SPIE Press Books Published in 1991 1992(SPIE 1991 Publications Index: Subject/author Indexes of All SPIE Proceedings and SPIE Press Books Published in 1991 1992](https://paperpile.com/c/6EoUIN/k8oY+Sidr)

[Balamurugan, S., Anupriya Jain, Sachin Sharma, Dinesh Goyal, Sonia Duggal, and Seema Sharma. 2021. Nature-Inspired Algorithms and Applications. John Wiley & Sons.](http://paperpile.com/b/6EoUIN/QbVY)

[Fourati, W., F. Kammoun, and M. S. Bouhlel. 2005. Medical Image Denoising Using Wavelet Thresholding.](http://paperpile.com/b/6EoUIN/2AqI)

[Gunarathne, G. P. P. 2013. Advancements and Breakthroughs in Ultrasound Imaging. BoD – Books on Demand.](http://paperpile.com/b/6EoUIN/Jex8)

[IEEE Staff. 2018. 2018 International Conference on Computing, Mathematics and Engineering Technologies (iCoMET).](http://paperpile.com/b/6EoUIN/XbDV)

[JJAP. 2007.](http://paperpile.com/b/6EoUIN/R3gr)

[Khare, Ashish. 2010. Wavelet Transform Based Techniques for Denoising Medical Images. LAP Lambert Academic Publishing.](http://paperpile.com/b/6EoUIN/wjYf)

[Koundal, Deepika, Savita Gupta, and Sukhwinder Singh. n.d. Applications of Neutrosophic Sets in Medical Image Denoising and Segmentation. Infinite Study.](http://paperpile.com/b/6EoUIN/mZWd)

[Kumar, Nalin, and M. Nachamai. 2017. “Noise Removal and Filtering Techniques Used in Medical Images.” Oriental Journal of Computer Science and Technology 10 (1): 103–13.](http://paperpile.com/b/6EoUIN/SmqK)

[Lang, A., P. Mousavi, and G. Fichtinger. 2009. “Fusion of Electromagnetic Tracking with Speckle-Tracked 3D Freehand Ultrasound Using an Unscented Kalman Filter.” Medical Imaging.](http://paperpile.com/b/6EoUIN/DUrU) <https://www.spiedigitallibrary.org/conference-proceedings-of-spie/7265/72651A/Fusion-of-electromagnetic-tracking-with-speckle-tracked-3D-freehand-ultrasound/10.1117/12.813879.short>[.](http://paperpile.com/b/6EoUIN/DUrU)

[Lekan, Michael D. 2009. Impact of Bilateral Filter Parameters on Medical Image Noise Reduction and Edge Preservation.](http://paperpile.com/b/6EoUIN/iiij)

[Paul, Manoranjan, Carlos Hitoshi, and Qingming Huang. 2018. Image and Video Technology: 8th Pacific-Rim Symposium, PSIVT 2017, Wuhan, China, November 20-24, 2017, Revised Selected Papers. Springer.](http://paperpile.com/b/6EoUIN/Sidr)

[Santosh, K. C., and Ravindra S. Hegadi. 2019. Recent Trends in Image Processing and Pattern Recognition: Second International Conference, RTIP2R 2018, Solapur, India, December 21–22, 2018, Revised Selected Papers, Part I. Springer.](http://paperpile.com/b/6EoUIN/EzGQ)

[Sharma, Renu, Manohar Mishra, Janmenjoy Nayak, Bighnaraj Naik, and Danilo Pelusi. 2020. Green Technology for Smart City and Society: Proceedings of GTSCS 2020. Springer Nature.](http://paperpile.com/b/6EoUIN/egDN)

[Soro, Alessandro, Margot Brereton, and Paul Roe. 2018. Social Internet of Things. Springer.](http://paperpile.com/b/6EoUIN/dLGg)

[SPIE 1991 Publications Index: Subject/author Indexes of All SPIE Proceedings and SPIE Press Books Published in 1991. 1992.](http://paperpile.com/b/6EoUIN/k8oY)

[Toennies, Klaus D. 2012. Guide to Medical Image Analysis: Methods and Algorithms. Springer Science & Business Media.](http://paperpile.com/b/6EoUIN/IfuU)

[Vaseghi, Saeed V. 1996. Advanced Signal Processing and Digital Noise Reduction.](http://paperpile.com/b/6EoUIN/7hd6)

[Zhang, Shuai, Zhiguo Zhang, S. C. Chan, Huiying Wen, and Xin Chen. 2015. “An Automatic Muscle Fiber Orientation Tracking Algorithm Using Bayesian Kalman Filter for Ultrasound Images.” In 2015 IEEE International Conference on Image Processing (ICIP), 3510–14.](http://paperpile.com/b/6EoUIN/H2HM)

[(SPIE 1991 Publications Index: Subject/author Indexes of All SPIE Proceedings and SPIE Press Books Published in 1991 1992; Paul, Hitoshi, and Huang 2018)](https://paperpile.com/c/6EoUIN/k8oY+Sidr)

**TABLES AND FIGURES**

**Table 1**. Comparison of prediction of accuracy between novel kalman filter and gabor filter. Novel kalman filter achieved an accuracy of 90.93% compared to the Gabor filter having 8615%.

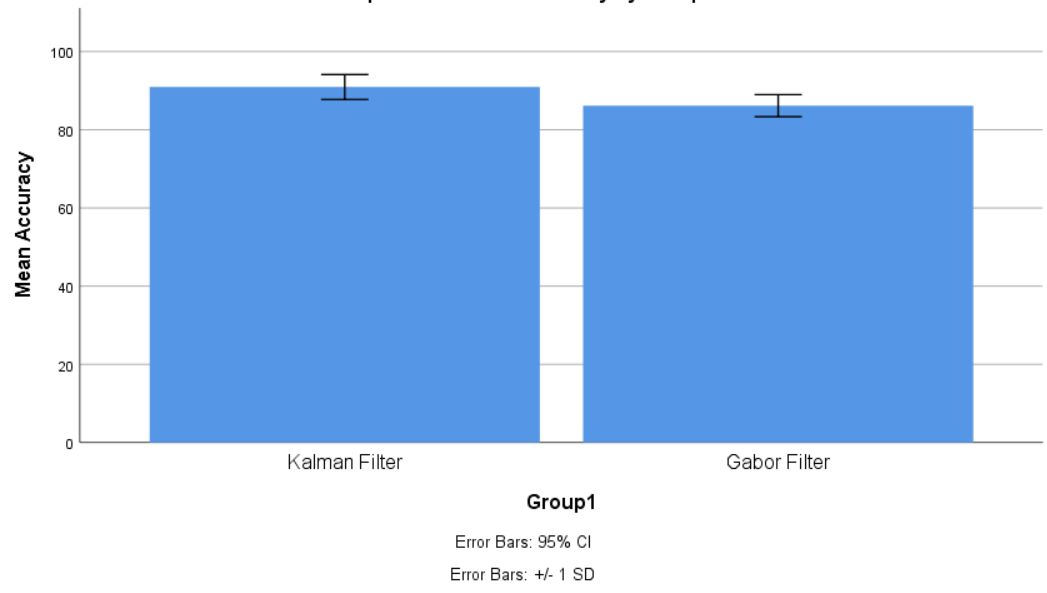
| **Sl.no** | **Novel kalman filter** | **Gabor filter** |
| --- | --- | --- |
| 1 | 90.93 | 86.15 |
| 2 | 91.49 | 95.96 |
| 3 | 90.83 | 84.98 |
| 4 | 89.56 | 83.94 |
| 5 | 88.98 | 82.88 |
| 6 | 87.59 | 81.75 |
| 7 | 86.98 | 80.69 |
| 8 | 85.94 | 79.87 |
| 9 | 84.99 | 78.96 |
| 10 | 83.56 | 77.58 |

**Table 2.**Mean, standard deviation, and standard error mean for , Novel Kalman Filter and gabor filter are given below.

| **Algorithm** | | **N** | **Mean** | **Standard Deviation** | **Standard Error Mean** |
| --- | --- | --- | --- | --- | --- |
| Accuracy | Novel Kalman Filter | 10 | 90.93 | 3.193 | 1.010 |
| Gabor | 10 | 86.15 | 2.823 | 0.893 |

**Table 3.** An independent sample T-test is performed for the two groups for significance and standard error determination. The significance value p=0.005 (p<0.05) shows that two groups are statistically significant.

|  | | **Levene’s test for equality of variables** | | **T-test for Equality of means** | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **F** | **Sig** | **t** | **df** | **Sig (2-tailed)** | **Mean Difference** | **Std. Error Difference** | **95% confidence interval of the Difference** | |
| **Lower** | **Upper** |
| **Accuracy** | Equal variances assumed | .213 | 0.650 | 3.544 | 18 | 0.005 | 4.777 | 1.348 | 1.945 | 7.609 |
| Equal variances not assumed |  |  | 3.544 | 18 | 0.005 | 4.777 | 1.348 | 1.942 | 7.612 |

****

**Graph**

**Fig. 1.** Comparison of Novel Kalman Filter and gabor filter in terms of mean accuracy . The mean accuracy of the gabor filter is better than the Novel Kalman Filter and the standard deviation of the gabor filter is slightly better than the Novel Kalman Filter. X Axis: gabor filterVs Novel Kalman Filter. Y Axis: Means Accuracy of Detection ±1 SD.