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Novel Optimized Framework for Video Processing in IoRT Driven Hospitals

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Abstract: Internet of Remote things (IoRT) has gained recent attention and is considered as one most prominent research topics being carried out by numerous researchers worldwide. IoRT is being used in various applications and this paper mainly concentrates on the healthcare industry wherein it could be used effectively for patient monitoring. IoRT plays a crucial role in monitoring the patients in any healthcare center remotely by allowing simultaneous video transmissions possible from the emergency areas like Intensive Care Unit (ICU). Considering general scenarios, the video transmissions are done by the main use of Gaussian distribution. With the help of the proposed IoRT based system, the video transmission could be effectively done by making use of short-term snapshots. This system enables a wide range of intermittent distributions. As the system basically works on multiple videos, denoising these videos is the primary challenge. Image-denoising is one of the important pre-processing stages, used to improve the overall quality of the images used in video transmission. The use of a Median Filter is done to minimize the overall Signal-to-Noise Ratio (SNR). Even though numerous types of Median filters are available, in this work we have made use of a 3D (Dimension) filter to get more effective results as the edges of the video frames are preserved. The paper has made use of a Hybrid algorithm combining the Cuckoo Search Optimization technique along with a Genetic Algorithm (GA) to optimize the frames in the video. The use of this hybrid algorithm paves a way to obtain equal intensity-based frames. For analyzing collective performance Peak Signal Noise Ratio (PSNR), Universal Image Quality Index (UIQI) and Structural Similarity Index (SSI) are used as quality assessment metrics to deliver a high-performance noise-free optimized video. The simulation results show better performance when compared with other image Noise Filtering Methods and other optimization algorithms when used in IoRT driven hospitals.

Keywords: Internet of remote things; signal-to-noise-ratio; median filtering; cuckoo search

1 Introduction

The Internet of Things (IoT) is without a doubt one of the most fascinating subjects in science, government, and industry. While the conventional internet allows for contact between a small range of devices and persons, the Internet of Things (IoT) integrates all types of connected "Things" through a vast collection of interrelated computing knowledge without the need for personal communication. Patients' health issues can now be delivered in real-time to physicians thanks to the introduction of IoT and the advancement of wireless communication technologies [1,2]. Most available sensors and portable devices may also calculate precise human physiological parameters such as heart rate (HR), rectal temperature (RR), and blood pressure (BP) with a single contact. Even though it is still in its early stages of growth, economic sectors have rapidly embraced the strength of IoT in their current systems, resulting in changes in both output and customer knowledge [3].

Technological advancements have provided sophisticated technologies to be applied to improve personal living standards. To generate insights and address health-related issues, researchers researching the advances in technology have studied and discussed health information from different sources. As a result, at every point of the supply chain, the advent of sophisticated medical technologies that have the potential to increase quality and patient outcomes. With comprehensive public health and safety controls, seamless access to data, virtual inpatient supervision, rapid therapeutic care, and decentralized electronic-healthcare records, the implementation of modern electronic-Health (eHealth) technology systems will solve many problems that plague conventional healthcare systems. These systems can handle health information and patient data, strengthen patients' quality of life, improve transparency, better clinical care, lower costs, and boost overall e-healthcare performance.

These devices, on the other hand, are distinguished by a high degree of heterogeneity [4], generating massive quantities of health and fitness data in disparate formats [5]. Hundreds of healthcare organizations face difficulties collecting data from various types of medical devices daily, impacting both patient care and medical science. All of this shared medical data, on the other hand, may be in a variety of formats and quality standards [6]. Even if all of this data is interoperable with each other in the future, transforming it all into a standard format would not suffice, since it is all extremely important because it drives medical decision-making [7]. Instead, it would be smarter and more productive to recognize the various levels of quality that this data can possess, and then convert only the data that is of high quality. The majority of existing solutions do not seek to reduce the contribution of different stimuli. As a result, numerous blended strategies for improving the graphical fidelity of a received image by eliminating different sounds have been developed. The optimal filtering for an input dataset is classified by the characteristics of clutter that has contaminated it. Filters are created for specific noise kinds; thus, right combination is required. At different noise levels, the order of eradicating Gaussian, specks, salt, and pepper disturbances would be primarily determined employing Cuckoo Search Algorithm (CSA) with PSNR as its weighting factor. The choice of CSA was based on its operational excellence in numerous domains over GA and Particle Swarm Optimization (PSO).

In real-world applications, extracting meaningful information from degraded photos without knowing the type of noise that has polluted them has been a challenge. Gaussian, speckle, and salt and pepper noise are examples of noises that can degrade visual textures. Linear filters, nonlinear filters, and wavelet threshold-based algorithms have all been developed to reduce noise and improve image quality. The majority of existing solutions do not seek to reduce the impacts of various noises. As a result, numerous hybrid strategies for improving the visual quality of a received image by removing numerous sounds have been developed. A hybrid technique by combining nonlinear filters, smoothing filters and optimization algorithm called cuckoo search was proposed in [8]. This combination in a sequence proves better when compared with other filters but the variant of CSA proves to be inefficient nowadays and various other metrics can be considered for removing all kinds of noise at different noise densities.

Noise is an unnecessary signal that can be triggered by a variety of factors in an image, including low light, slow trigger, sensor fill factor, and sensor heat, among others. Impulse Noise is caused by a sudden and rapid distortion in the picture signal, which may result in white and/or dark spots. It appears as a smattering of white and black pixels. Most filters are being developed to minimize or eliminate impulse noise and to recreate an image that is close to the original. Factors such as noise removal complexity and the imperfection of the denoising algorithm make obtaining an accurate version of the entire image after processing nearly impossible. A small black spot consisting of one or more pixels in a uniform green region of an image, for example, might not be noise. Second, the shape of these pixels may be either normal or irregular. Regular shapes may be formed as a result of a sensor defect, while the irregular shape may be a true feature of the image. Furthermore, in some situations, such as astronomical photographs, impulse reduction is not a problem for extracting a small amount of information hidden in a clump of noise. Furthermore, incomplete algorithms lead to issues such as the loss of important features during processing or the retention of certain noise [9].

Many filtering algorithms are proposed by researchers but then the median filtering provides better results of removing noise and maintaining the features of the original video. The noise removal process doesn't mean that the video frames get optimized as per the required output. So, the denoised frames need to be optimized. Various optimization algorithms are researched but the proposed Cuckoo Search-based optimization techniques provide better optimization results using convolution networks.

In a nutshell the main contributions of the work are:

- Video-Input and segregated as frames and denoised using Adaptive 3D median filtering
- The denoised frames are optimized using the Cuckoo Search optimization technique based on convolution neural networks.
- Finally, the optimized frames are combined to produce a high-quality video.

The rest of the paper is organized as follows: Section 2 provides a detailed review of various contributions through algorithms by researchers for optimization and denoising. Section 3 provides a detailed description of the proposed framework for denoising and optimization. Section 4 gives the implementation results of the proposed work. Finally, Section 5 concludes the work, deliberates the limitations and delights the direction of possible future work.

2 Related Work

The most important task in video processing is to remove noise from video frames that have been ruined by a variety of factors such as poor focusing, the inadequacy of imaging devices, motion, and so on. The methods for removing noise help to provide the valuable features of photographs that aren't easily noticed. It's employed in a variety of fields, including astronomy, forensic science, and, most notably, medicine, when more consistent ways for achieving precise results are required. The right de-noising technique is chosen based on the application in which understanding the noises in an image are essential. There are many different types of noises. Gaussian noise, speckle noise, Rayleigh noise, exponential noise, Erlang noise, impulse noise, and uniform noise are the different types of noise. Among these noises, impulse noise is the most typically encountered in video frames. It's also known as salt and pepper noise because impulse noise resembles a sprinkling of salt and pepper. Appropriate filters are to be used to eliminate these noises.

The two stages fuzzy logic–based hybrid filter for the elimination of impulse noise from the standard test images was proposed by in [10], which proves the visual quality and PSNR is increased when compared to some existing filters but it fails to optimize the images that leads to loss of image features.

Improved Adaptive Median Filtering Algorithm-I (IAMFA-I) and Improved Adaptive Median Filtering Algorithm-II (IAMFA-II) algorithms were proposed in [11] which reduces the probability of choosing impulse values that are provided for denoising tasks. This filter mainly concentrates on impulse noises and denoising other types of noise are less effective.

Mostly the noise occurrence is due to fault in storage or transmission or chip level which leads to impulse noise. So, to reduce such noise a Decision Based Adaptive Median Filter (DBAMF) [12] for diverse Salt and Pepper Noise (SPN) environment was proposed. But this method uses too many filters to prove the efficiency of DBAMF which reduces the image restoration clarity.

In the medical field, most of the image and video processing deals with Electroencephalogram (EEG), electrocardiogram (ECG) and mammograms. The processing of such images needs efficient filters. A decision tree-based algorithm proficient in conserving satisfactory details of the image is proposed in [13] for the removal of high-density outlier noise in mammogram images which are categorized as salt and pepper noises. This one proves good for only certain noises at high density but for other types of noises, the algorithm needs to be improved.

Researchers have recently focused their attention on the topic of optimization, particularly hybrid metaheuristics. A meta-heuristic is an elevated technique for finding, generating, or selecting a heuristic (partial search algorithm) that can solve an optimization issue sufficiently well [14]. Single solution-based and population based [15] meta-heuristic algorithms, nature-inspired and non-nature inspired [16] meta-heuristic algorithms, metaphor-based and non-metaphor-based algorithms [17], and so on. These techniques can be generally classified into four groups in terms of ‘creativity': swarm-inspired, physics-based, and human-related evolution [18].

Digital images become corrupted during picture acquisition and transmission due to disruption in the communication channel. The most damaging noises are Salt & Pepper (SPN) and Random Valued Impulse Noise (RVIN). Various non-linear filters are used, including Simple Median Filter (SMF), Tri-State Median Filter (TSMF), Progressive Switching Median Filter (PSWMF), Center-Weighted Median Filter (CWMF), and Adaptive Centre Weight Median Filter (ACWMF), with the last two producing better results than SMF. These filters are used to eliminate RVIN: Dip-Steered Median Filter (DSMF), Directional Weighted Median Filter (DWMF), Second Order Difference Based Impulse Detection Filter (SO-DBIDF), Modified Weight Based Filter (MWBF), and Modified Directional Weighted Median Based Filter (MDWMBF). Apart from the aforesaid Mean and Median filters, Fuzzy-based and Neuro-Fuzzy based filters outperform Soft Computing-based filters in terms of PSNR in decibels (dB). To counter such problems in [19] genetic algorithm-based optimization technique was proposed which yielded results about specific noise and certain noise density levels.

Over the years, meta-heuristic optimization algorithms have been employed for Feature Selection (FS) because they can overcome the limitations of present optimization approaches. In [20], combined optimization technique of Adaptive-Hill Climbing (AHC) was proposed with the Binary Sailfish (BSF) optimizer to boost the BSF optimizer's exploitation capacity to solve the feature selection problem which proves good in feature selection aspect.

The Pulse Coupled Neural Network (PCNN) has gotten a lot of press as a nonlinear filtering technology for noise reduction while preserving picture information, however choosing the proper parameters for PCNN is a challenging issue. To handle such an issue [21] proposed Genetic Algorithm based PCNN called GACA-PCNN (Genetic Ant Colony Algorithm–PCNN) which provides reasonable denoising of images with better PSNR value and restoration of information is also proven effective. But the equal intensity and quality of the image restoration is less effective.

The appropriate filter for a given image is determined by the type of noise that has polluted it. Filters are created for specific noise types; thus, careful selection is required. So, from the literature study it is evident to

propose an adaptive 3D median filtering along with the optimization technique of Cuckoo Search Algorithm and Adaptive Binary Sailfish Optimizer with 3 objective functions which is being described in the subsequent sections and the results are found to more effective when compared to state-of-art filters with minimal objective functions.

3 Proposed Work

In this era of technological advancement, the Internet of Things (IoT) has acquired widespread acceptance. IoT is the linking of multiple computing devices in web infrastructure. We use a variety of smart devices in our daily lives, including our smart phones, automobiles, household appliances, electrical devices, and so on. IoT is an interface that supports all of your devices and makes operating them much more efficient by centralizing them. Automobiles, industrial equipment, healthcare, smart homes, and even entertainment are among the numerous industries where IoT is widely used.

As a result, the issue emerges between the need for diverse devices' derived data to be completely interoperable on the one side, and the challenge of determining the accuracy of such a massive amount of data on the other. As a result, it's critical to figure out not only how to make the derived data from these devices interoperable, but also how to measure the consistency of this whole information so that the compatibility improvements can be applied only to this data. Another major challenge is contemplating the noise generated in the data collected from various heterogenic devices. Users of these applications, on the other hand, experience quality loss as a result of image transmission over networks. In real-world applications, extracting valuable information from degraded images without knowing the sort of noise that has contaminated them has been a challenge. Gaussian, speckle, and salt and pepper noise are examples of noises that can degrade picture textures.

Image analysis is an important aspect of medical imaging. In recent years, the area of image processing has advanced to the point that sophisticated algorithms can now diagnose cancers, cysts, and other conditions. Despite the tremendous advancements in optical sensors in recent years, chromatic aberration remains an important step in video processing, notably when shooting in difficult situations.

To rectify the problems provided in the literature survey of existing works a novel framework is proposed not only to denoise the video frames but also to optimize them to get a quality video. The proposed work is categorized as follows which is depicted in Fig. 1:

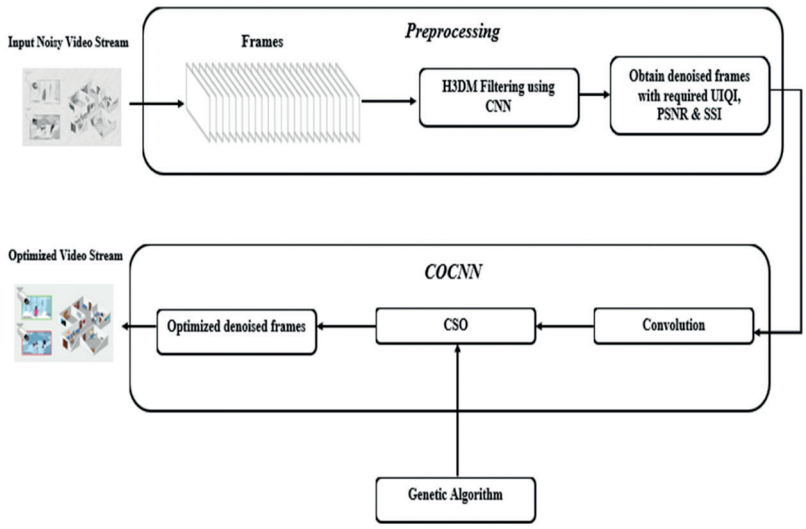


Figure 1: Proposed architecture framework

- The input video is categorized as frames through Convolution Neural Network (CNN).
- Converted video frames are sent to Hybrid 3 Dimension Median (H3DM) filter to denoise the frames and obtain UIQI, PSNR, SSI where PSNR considered to be producing low value and UIQI and SSI high value which is utilized as Objective Function for Optimization.
- The denoised frames are optimized using the proposed Cuckoo Optimized Convolution Neural Network (COCNN) algorithm to get high-quality denoised video frames which are then used for blending the video.

3.1 Denoising Through H3DM Filtering Using CNN

The video streams generated from IoT devices have a lot of noise which can be salt & pepper, Gaussian, impulse noise, speckle noise, exponential noise, Erlang noise and Rayleigh noise. The detection of the type of noise and removal of it is a difficult process as the video streams received are from heterogeneous devices and IoT data are huge. Video denoising is the vital pre-processing stage in video analysis which is used to provide qualitative information for the analysis. To denoise the video stream first the video stream needs to be converted to frames. The pre-processing features of the proposed system is converting it into frames and remove the noise using a Hybrid form of 3D median filtering and estimate the functional parameters of the video frames.

The input video is converted to 3 frames with a model map and the frames are convoluted by shuffling the pixels finally the shuffled pixels are combined with input and final denoised video frames are generated based on U-Net. This is depicted in Fig. 2.

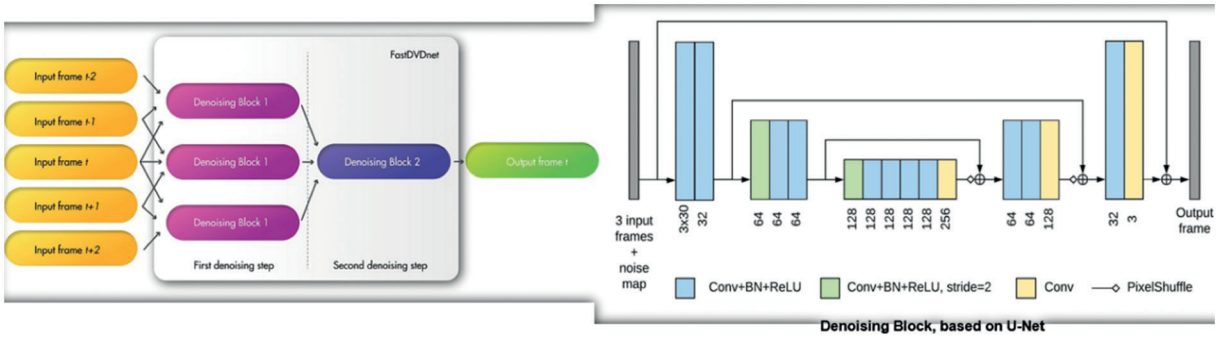


Figure 2: System architectural view

Proposed Algorithm

The below-given algorithm describes how the proposed algorithm works. The input is based on setting up the parameters required for the proposed to be efficient one by choosing the initial population in random and iterations are applied. If the values of the iteration are less, then calculate the fitness to compare. If the values are higher, selection process is carried out to get the appropriate fitness value with the best values.

Input: Setting the parameter

Choose encode scheme

Generating the population in initial

Population in random

Condition applied

If values of iteration are less **then**

Calculate the fitness and compare

Else

Selection process

Again, condition applied

End if

Decode the maximum fitness values

Repeat the values gain and gain to get the best values

Output: The best values with maximum iteration

3.2 Optimization of Denoised Frames Using COCNN

The idea for CSA is based on the behavior of a bird species known as the cuckoo, which is known for its unique manner of life and aggressive reproduction approach. Cuckoos lay their eggs in the nests of the host birds, and they have a remarkable capacity to select the nest and remove existing eggs to increase the odds of hatching. The host birds either fight cuckoos by tossing their eggs away, or they create their nests elsewhere. Cuckoos go on random walks in search of a fresh site to lay their eggs. Other insects, such as fruit flies, explore their environment by flying through straight lines punctuated by a sudden 90-degree turn, which is similar to their random walk. Because of the randomization process, CSA is popular among other optimization techniques. Cuckoos in CSA do random walks, making the algorithm's solutions more random and optimal. CSA, unlike GA, does not become stuck in the local optimum as a result of this randomization. Another advantage of CSA over other optimization algorithms is that tweaking CSA requires a smaller number of parameters. To get the best outcomes, only the initial population of nests and the likelihood of identifying bad nests are changed. We employed CSA to establish the optimal sequence of filters in the suggested algorithm because of its usefulness in addressing optimization challenges.

As per the algorithm defined in 3.1.1 the denoised video frames are optimized through the Cuckoo Search Algorithm which stands out of all other optimized algorithm. The scheme flow of the algorithm is given in Fig. 3. The figure explains that the initial population is randomly generated and fitness values are evaluated compared and if it is found less the comparison is again performed through the Random Flight method and find out the best values of the fitness value. Once the iteration reached the maximum value then the best of the value is chosen and the process is continued till the best value for fitness is generated.

CSA will discover the best sequences to remove a specific sort of noise from a video frame. Following the formation of nests, their fitness will be assessed using the Eq. (1) objective function based on which the UIQI and SSI is estimated:

$$Obj\_func() = PSNR \tag{1}$$

3.3 Embedded Device

It has enabled the development of more powerful computing devices with small footprints that can execute fundamental analytics and identification activities without depending on cloud architecture. On the other hand, advancements in IoT protocol have made it possible to operate networks with a large number of nodes with minimal latency and great stability. The internet era has resulted in the introduction of several devices that are utilized in a variety of applications. Communication between devices deployed in a specific application is critical since it is their primary role to communicate and conduct various operations within the environment in which they are installed. We come across many of these gadgets in our homes, offices, autos, and a variety of other manufacturing units, which are now frequently referred

to as ‘Smart Devices.’ When a gadget can communicate with other devices in its surroundings and fulfill its functions, it is referred to as a smart device.

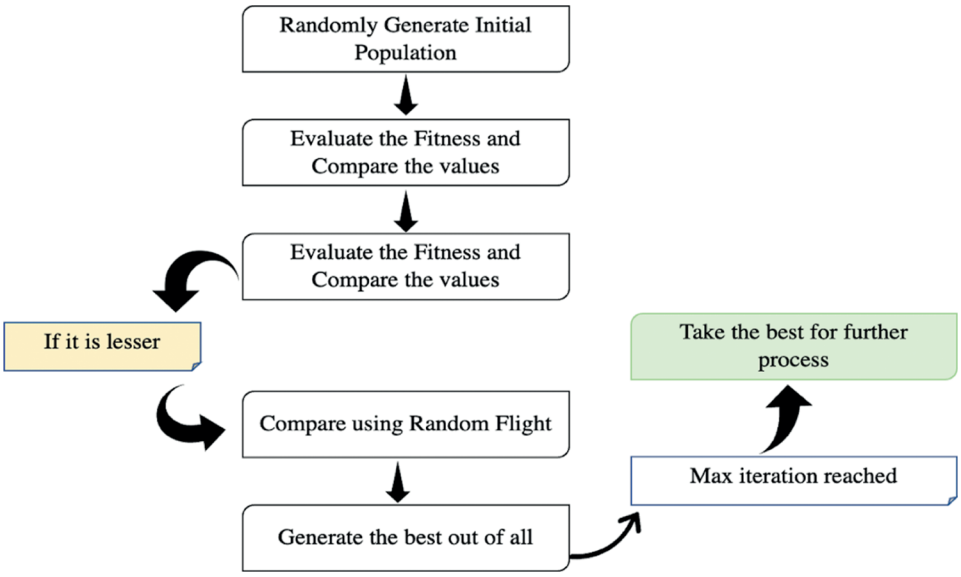


Figure 3: Flow scheme with conditions

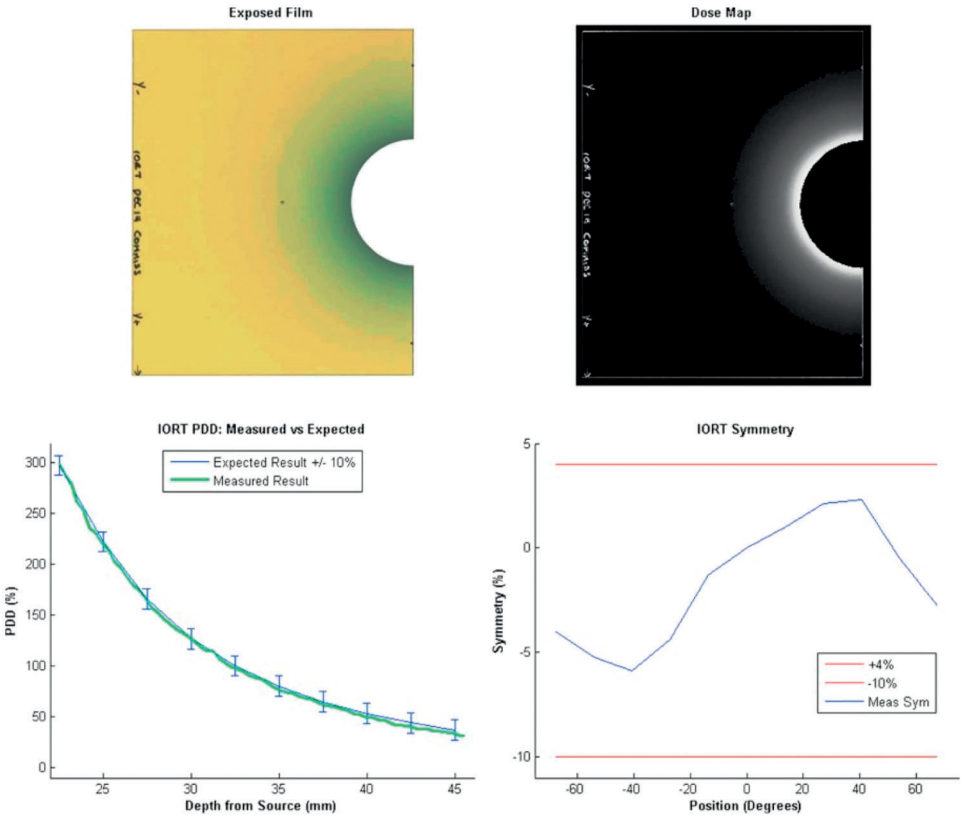
4 Performance Evaluation

This section gives the evaluation performance of the proposed system which is performed on video which contains noises at a different level of depreciation. The input video is converted into frames and denoised through the proposed convolution method by removing different levels of noises. The denoised video frames are optimized through cuckoo search algorithm by using the objective function as PSNR which proves to be proficient. Because solo filters generate blurs and are ineffective at noise removal, the suggested approach's results are more than adequate. Fig. 4a shows the IoRT measured *vs.* expected comparison where the measured value is more equivalent to the expected value. Fig. 4b gives the overall mean symmetry of IoRT performance.

Fig. 5 shows the performance of PSNR against all the state of art filters and it is proven that the proposed filter works better and provides better quality of video frames with better PSNR value. The average increase in PSNR against all filters was around 30 and that of the proposed filter is found to be 31 and it is mainly compared with Video Denoising using CNN (ViDeNN) algorithm. Fig. 5a shows how the state-of-art-filters such as Video Non-Local Bayes (VNLB), Video-Block Matching 4 Dimension (V-BM4D), Video Non-Local Network (VNLnet), and Deep Video Denoising Network (DVDnet) performed in eliminating Gaussian Noise. Fig. 5b shows the Clipped Gaussian Noise elimination comparison of ViDeNN algorithm with Fast Deep Video Denoising Network (FastDVDnet) filter because other state-of-art filters proven less effective.

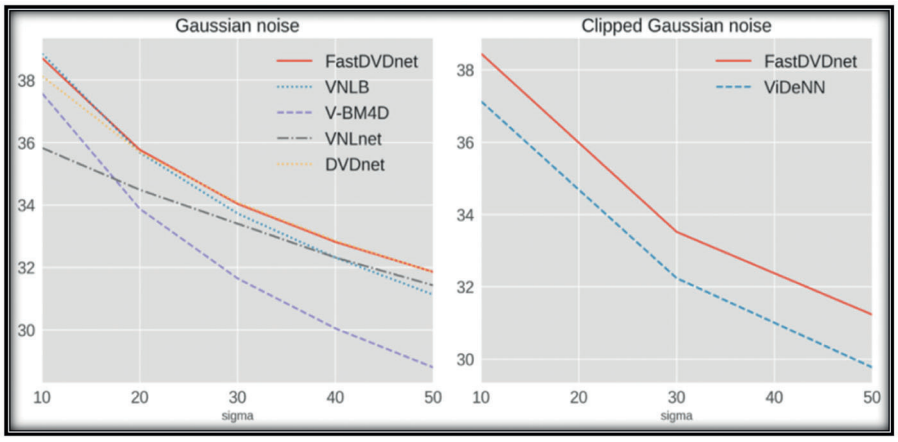
Visual comparisons also reveal that the bilateral filter, being a nonlinear filter, which is specifically designed for Gaussian noise, better preserves edges and results at higher PSNR values. Despite this fact, the performance of the proposed filter is satisfactory as can be seen in the visual comparison. The suggested filter's lower PSNR value is due to its inefficiency in edge preservation, not noise suppression, as can be seen from the visual comparison. The proposed filter produced greater PSNR values. The reason for this is that PSNR is the CSA's objective function, and all filter sequences are compared to it.

In terms of PSNR, SSI, and UIQI, the hybrid filter surpasses the three-wavelet shrinking approaches. Visual comparisons reveal that they obliterate image textures and contrast, which is the primary cause of their lower PSNR, SSI, and UIQI scores. The suggested filter's denoising results are also compared to those of the median filter, which is widely used for removing salt and pepper noise.



(a) Analysis of IoRT Measured vs Expected (b) IoRT Symmetry

Figure 4: IoRT performance measure



(a) Filters Performance (b) ViDeNN vs. FastDVDnet

Figure 5: Performance comparison chart of various filters against gaussian noise

Wavelets and nonlinear filters both failed to eliminate salt and pepper noise. It's worth noting that the sequence that removes salt and pepper noise includes not only the median filter, which is well-known for removing salt and pepper noise, but also a combination of median 3 × 3, median 5 × 5, cone, and Gaussian. As a result, even if the noise is unknown, CSA discovers an ideal sequence to reduce it. This is the real advantage of the proposed filter.

Fig. 6 reveals that the proposed filter and algorithm for optimization proves to be best in denoising the video frames and also optimizing them. The runtime functionality along with Graphic Processing Unit (GPU) and Central Processing Unit (CPU) also proves the proposed hybrid filter needs less time for optimizing and denoising the video frames. The fact that the suggested filter outperforms the other hybrid filter in terms of PSNR over all frames.

The following is a list of the contributions made by this research project:

- Using multiple filters in a sequence improved denoising performance.
- Investigated the CSA as a technique for optimization.
- Created a hybrid denoising technique for video frames.
- Developed a more dependable denoising method that outperforms previous strategies in terms of image denoising.
- Researched the effects of various denoising algorithms on various types of noises at various levels of noise intensity.

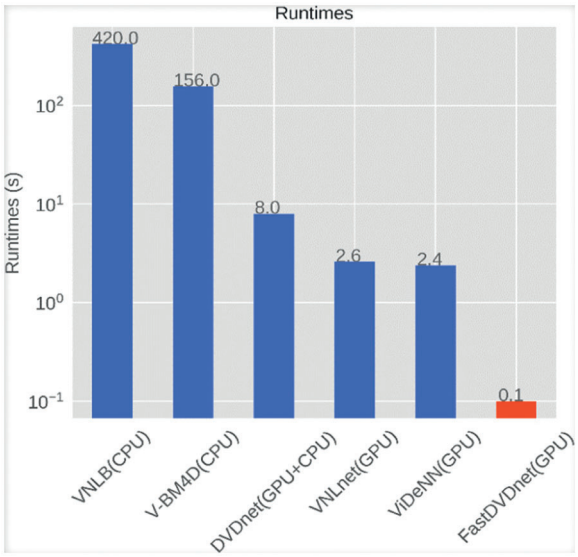


Figure 6: Comparison of various filters runtime complexity

5 Conclusion

Image denoising research is still in high demand as the complexity and specifications of the process have grown. In this paper, we have discussed the merits and drawbacks of several image denoising methods that have recently been developed. Despite numerous in-depth researches on Additive White Gaussian Noise (AWGN) elimination, very few accepted as true object denoising. Since AWGN is much easier than realistic noises, the only stumbling block is the difficulty of real noises. A detailed examination of a denoiser is a challenging job in this case. The in-camera pipeline contains multiple elements (such as white balance, color demos icing, noise removal, color transition, and compaction). Some different

factors, such as lighting, Charged Coupled Device/Complementary Metal-Oxide Semiconductor (CCD/CMOS) sensors, and camera shake, affect the performance image quality. Using extensive simulations, this paper analyses the median filter and its diverse variants for minimizing or eliminating noisy pixels from grayscale images. In comparison to other methods, our research findings show that the best filters in the fields of interference detection and filtering yield good results. This paper provides a complete relative analysis of various filters with median filter variants using widespread simulation for removing or decreasing the noisy pixels. Thus, by the process the degraded images are converted to high-quality images. Cuckoo Search Algorithm with CNN-based optimization is carried out on the denoised video frames to get high-quality video frames. The objective function used provides better results. The simulation results show a good PSNR value, better UIQI and SSI value for the median filter variants at all noise density levels. The noise density level is achieved at a threshold of 90%–93% when compared to other filters. The simulations show further productive in exposure of source in IoRT where the expected and measured results are proves to be similar in terms of Percentage Depth Dose (PDD). The mean symmetry of IoRT is also found between the range +4% and −10% which is better when compared to other filters. The main aim of proposed to remove the minute level noises and also higher-level noises which is achieved through the efficient 3D Median Filter in combination with optimization algorithm Cuckoo Search Algorithm (CSA) The Genetic Algorithm (GA) applied for the optimization results in achieving the best value for the denoised frames. The video frames optimized through CSA in combination with GA provides resultant frames with optimized value greater than 80% when compared with other optimization algorithms.

As a research paper, we define a variety of median alternatives and suggest three-way image segmentation decisions, including approved, denied, and delayed noise elevations. When a pixel's intensity falls below a certain threshold, it is approved or refused as not corrupted or skewed, respectively; Even so, to determine its appropriate location, the decision will make use of more surrounding pixels. Cognitive and genomic algorithms can be used in comparison to other techniques to find exact local and global solutions, as well as to mitigate the use of approaches that result in haze in the final picture, thanks to their increasing popularity.

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