De-noising filter for impulse noise in Glacier ice Infrared images

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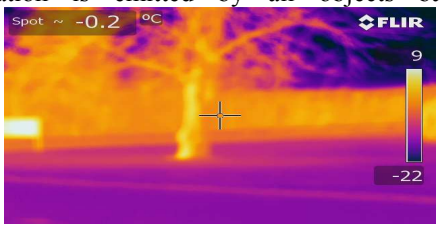
Abstract:- **Infrared (IR) imaging helps to capture the images with different temperature range and also captures better quality images during night time. Infrared Thermography is an emerging technology for nondestructive testing. So infrared images are considered to identify and classify ice types of river ice. However, it is subject to blurring and degradation of the acquired signal, as the diffusive nature in the process. This makes difficulties for qualitative and quantitative analyses, especially when deeper defects which are located within the substrate, as well as high thermal conductivity materials are inspected. The IR images usually have noise, edges, text information and small objects of interest. Non linear filters such as standard median filter however often tends to remove fine details in the image, such as thin lines and corners. So to overcome the drawback of median filter, relaxed median filter, adaptive median filter, decision based median filter and untrimmed decision based median filters are used for denoising. The results of all the filters are compared by using peak signal to noise ratio (PSNR) and mean square error (MSE), and found that untrimmed decision based median filter (UDBMF) gives higher results.**

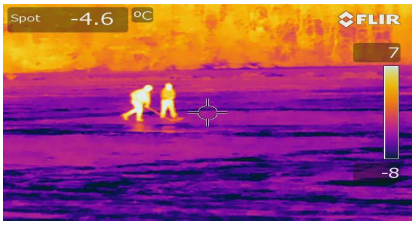
Keywords- **De-noising, infrared image, median filter, relaxed median filter, adaptive median filter, decision based median filter and UDBMF.**

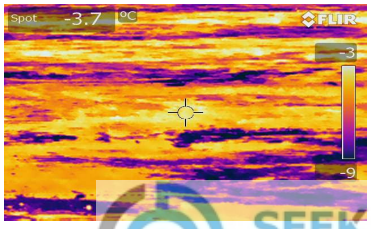
1. INTRODUCTION

IR light is electromagnetic radiation with a wavelength longer than that of visible light, measured from the nominal edge of visible red light at 0.74 micrometers (μm) and extending conventionally up to 300 μm. IR is used in night vision equipment when there is insufficient visible light to see. Night vision devices operate through a process involving the conversion of ambient light photons into electrons which are then amplified by a chemical and electrical process and then converted back into visible light. The use of infrared light and night vision devices should not be confused with thermal imaging which creates images based on differences in surface temperature by detecting infrared radiation (heat) that emanates from objects and their surrounding environment. Infrared radiation is emitted by all objects based on their temperatures, according to the black body radiation law, thermography makes it possible to "see" one's environment with or without visible illumination. The amount of radiation emitted by an object increases with temperature, therefore thermography allows one to see variations in temperature. Infrared imaging is used extensively for military and civilian purposes. Military applications include target acquisition, night vision, homing and tracking and surveillance. Non-military uses include thermal efficiency analysis, environmental monitoring, industrial facility inspections, remote temperature sensing, short-ranged wireless communication, spectroscopy and weather fore-casting. Infrared astronomy uses sensor-equipped telescopes to penetrate dusty regions of space, such as molecular clouds detect objects such as planets and to view highly red-shifted objects from the early days of the universe.

Scientist have reported that Canada in just six years has lost nearly 50 percent of the massive ice shelf area that holds back glacial ice from melting into the ocean. Two of Canada's biggest ice shelves diminished significantly this summer, one nearly disappearing altogether. The two are among six that make up Canada's biggest shelves, all located on Ellesmere Island. The loss is important as a marker of global warming. Due to global warming winter temperatures have risen by about 1.8 degrees Fahrenheit per decade for the past five to six decades on northern Ellesmere Island. Derek Mueller, an assistant professor at Carleton University, said the loss this past summer equals up to three billion tons of ice. So, Infrared ice images are used to study the ice condition of Canadian environment. The ice images are captured with FLIR T640 IR camera. The size of the images are 640 x 480 (307,200 pixels) for greater accuracy and readability from longer range distances. FLIR T640 IR camera captures the image with the temperature ranging from -40°C to +2000°C [26].







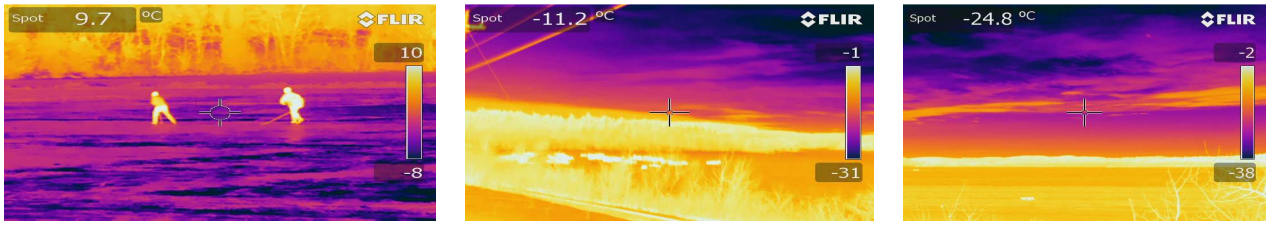


FIG. 1: infrared ice images with varying temperature range.

The method used in this paper has been organized in the following manner, section 2 describes identification of noise type in IR images, section 3 describes identified filters for IR images, section 4 describes implementation and analysis, section 5 describes the results and discussions, section 6 gives conclusion and finally all the references been made for completion of this work.

2. IDENTIFICATION OF NOISE TYPE IN IR IMAGES

Noise is an important defect in the image that can take many different forms and arises from various sources. Noise is a disturbance that affects a signal and may distort the information carried by the signal. Noise gets introduced into the data via any electrical system used for storage, transmission, and/or image acquisition process. In addition, nature will always plays a "noisy" trick or two with the data under observation. When encountering an image corrupted with noise you will want to improve its appearance for a specific application. The techniques applied are application-oriented. Also, the different procedures are related to the types of noise introduced to the image. Some examples of noise are: Gaussian or White, Rayleigh, Shot or Impulse, periodic, sinusoidal or coherent, uncorrelated, and granular [11].

Infrared images are affected with impulse noise during image acquisition, impulse noise detection and removal is an important process as the images are corrupted by those noises because of transmission and acquisition. The main aim of the noise removal is to suppress the noise while preserving the edge information. Images and videos belong to the most important information carriers in today's world. However, the images are likely to be corrupted by noise due to bad acquisition, transmission or recording. Such degradation negatively influences the performance of many image processing techniques and a preprocessing module to filter the images is often required.

3. IDENTIFIED FILTERS FOR INFRARED IMAGES

In this study, Non linear filters such as median filter, adaptive median filter, relaxed median filter, decision based median filter and UDBMF are considered. A median filter smooth's the data while keeping the small and sharp details. In a median filter, a window slides across the data and the median value of the samples inside the window is chosen to be the output of the filter. The median is a stronger "central indicator" than the average. In particular, the median is hardly affected by a small number of discrepant values among the pixels in the neighborhood. Consequently, median filtering is very effective at removing various kinds of noise. This non linear filter, compared to linear ones, shows certain advantages: edge preservation and efficient noise attenuation with robustness against impulsive noise type [25].

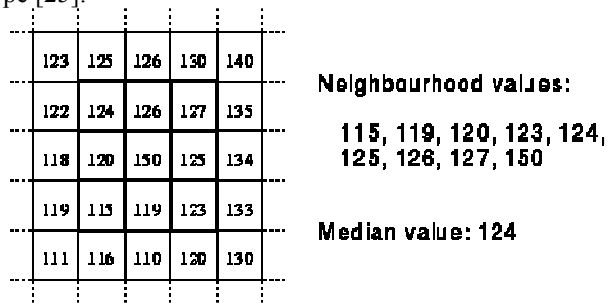


Fig. 2: Calculating the median value of a pixel neighborhood

In order to explain how to perform the noise detection, we must define some parameters of image pixels. x and y represent the horizontal and vertical coordinates of a pixel respectively. p(x,y) is the pixel with coordinates x and y. g(x,y) is the gray-level of the pixel p(x,y). S_{xy} is the set that includes g(x,y) and its neighbor pixels. For example, a 3×3 window, S_{xy} = {g(x - 1,y - 1), g(x, y - 1), g(x + 1, y - 1), g(x - 1, y), g(x, y), g(x + 1, y), g(x - 1, y + 1), g(x, y + 1), g(x + 1, y + 1)}, gm is the median gray-level of the S_{xy}. g(x, y) represents the gray-level of the central position pixel that will be processed, (s, t) denotes the coordinates of the pixels belonging to S_{xy}, and g(s, t) represents the gray- level of the pixels belonging to S_{xy} [16].

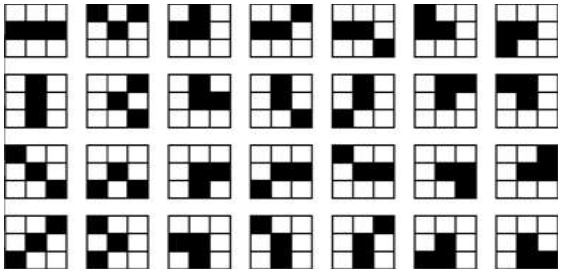


Fig. 3: Comparisons of central pixel to its two neighbor's pixels in 3×3 Window

The median filter removes both the noise and the fine detail since it can't tell the difference between the two. To overcome the drawback of median filter, a median based filter called relaxed median filter is used [17, 18]. The output of relaxed median filter is determined by comparing a lower and upper order statistics to the center sample in the filter window. The filtering operation of the relaxed median filter is controlled with the lower and upper filter bounds

which give the filter designer some freedom to determine the trade-off between noise and detail preservation. Relaxed median filter is far from being a perfect filtering method since it will enhance fine details, sharp corners and thin lines for less noise. Relaxed median filter does not provide good de-noising results when the noise is of 30% or more. The main reason is that the ordering process destroys any structural and spatial neighborhood information. So to overcome this drawback adaptive median filter is used.

Adaptive median filter performs well at low noise densities. But at high noise densities the window size has to be increased which may lead to blurring the image. In switching median filter, the decision is based on a pre-defined threshold value [25]. The major drawback of this method is that defining a robust decision is difficult. Also these filters will not take into account the local features as a result of which details and edges may not be recovered satisfactorily, especially when the noise level is high. To overcome the above drawback, decision based algorithm is used. In this, infrared images are de-noised by using a 3×3 window. If the processing pixel value is 0 or 255 it is processed or else it is left unchanged [10, 12-14].

In UDBMF, the selected 3 x 3 window elements are arranged in either increasing or decreasing order. Then the pixel values 0's and 255's in the image are removed from the image. Then the median value of the remaining pixels is taken. This median value is used to replace the noisy pixel. This filter is called trimmed median filter because the pixel values 0's and 255's are removed from the selected window. The processing pixel is checked whether it is noisy or noisy free. That is, if the processing pixel lies between maximum and minimum gray level values then it is noise free pixel, it is left unchanged. If the processing pixel takes the maximum or minimum gray level then it is noisy pixel which is processed by untrimmed decision based median filter [23, 24].

4. IMPLEMENTATION AND ANALYSIS

Scientist have reported that Canada in just six years has lost nearly 50 percent of the massive ice shelf area that holds back ice from melting into the ocean. So, Infrared ice images are used to study the ice condition of Canadian environment. The ice images are captured with FLIR T640 IR camera. The size of the images are 640 x 480 (307,200 pixels) for greater accuracy and readability from longer range distances. FLIR T640 IR camera captures the image with the temperature ranging from -40°C to +2000°C. The methodology is examined with infrared images with the temperature ranging from -24^{0}C to 9^{0}C. Infrared images are filtered by using median filter, relaxed median filter, adaptive median filter, decision based median filter and untrimmed decision based median filter. Table.1 provides the results of median filter, relaxed median filter, adaptive median filter, decision based median filter and untrimmed decision based median filter. Table.2 shows the calculated PSNR and MSE values for these filters.

Peak Signal-to-Noise Ratio (PSNR) is the ratio between the reference signal and the distortion signal in an image, given in decibels. The higher the PSNR, the closer the distorted image is to the original. For images A = {a1 ... aM}, B = {b1 ... bM}, and MAX equal to the maximum possible pixel value (2^8 - 1 = 255 for 8-bit images):

$$PSNR(A, B) = 10\log_{10}(\frac{MAX^2}{MSE(A, B)})$$

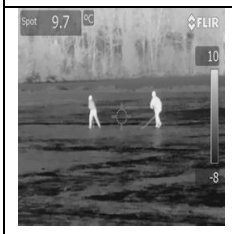
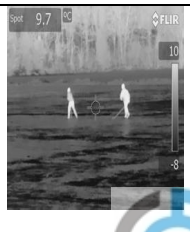
Mean Squared Error (MSE) is the average squared difference between a reference image and a distorted image. It is computed pixel-by-pixel by adding up the squared differences of all the pixels and dividing by the total pixel count. For images A = {a1 ... aM} and B = {b1 ... bM}, where M is the number of pixels:

$$MSE(A, B) = 1/M \sum_{i=1}^{M}(a_i - b_i)^2$$

5. RESULTS AND DISCUSSIONS

The results are generated by using matlab simulations. The methodology is examined with infrared images with the temperature ranging from -24^{0}C to 9^{0}C. Infrared images are filtered by using median filter, relaxed median filter, adaptive median filter, decision based median filter and untrimmed decision based median filter. Table.1 provides the results of median filter, relaxed median filter, adaptive median filter, decision based median filter and untrimmed decision based median filter. The performances of all these filters are tested by using the performance metrics such as PSNR and MSE.Table.2 shows the calculated PSNR and MSE values for these filters and found that untrimmed decision based median filters produces the highest results.

TABLE.1: RESULTS OF MEDIAN FILTER, RELAXED MEDIAN FILTER, ADAPTIVE MEDIAN FILTER, DECISION BASED MEDIAN FILTER AND UNTRIMMED DECISION BASED MEDIAN FILTER

Original images	Median filter	Relaxed Median filter	Adaptive Median filter	Decision based Median filter	UDBMF
					

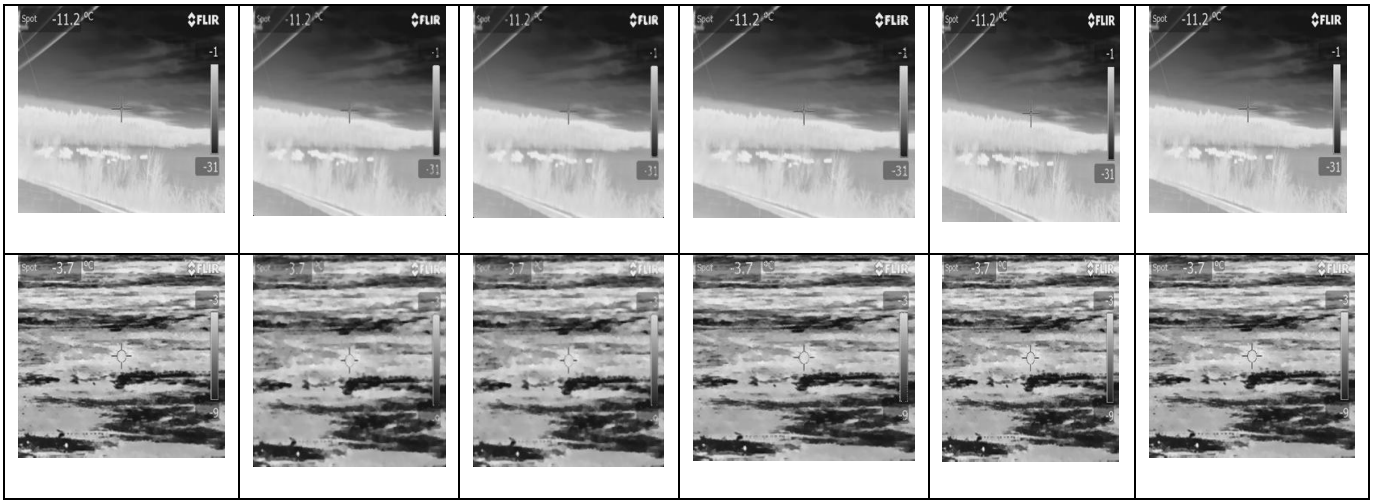
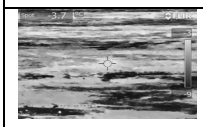
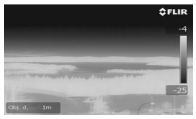
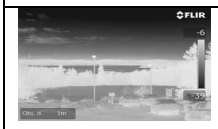


TABLE 2: PSNR AND MSE VALUES OF MEDIAN FILTER, RELAXED MEDIAN FILTER, ADAPTIVE MEDIAN FILTER, DECISION BASED MEDIAN FILTER AND UNTRIMMED DECISION BASED MEDIAN FILTER.

Image	Median filter		Relaxed Median filter		Adaptive Median filter		Decision based Median filter		UDBMF	
	PSNR	MSE	PSNR	MSE	PSNR	MSE	PSNR	MSE	PSNR	MSE
	32.3	6.19	32.31	6.15	37.55	3.38	56.7	0.37	**57.11**	**0.36**
	32.95	5.74	32.99	5.71	38	3.21	56.42	0.39	**57.1**	**0.36**
	33.01	5.7	33.04	5.66	37.93	3.24	57.02	0.36	**59.24**	**0.28**
	30.3	7.79	30.32	7.73	35.85	4.11	44.88	1.45	**45.16**	**1.41**
	31.78	6.57	31.81	6.54	37.18	3.53	48.76	0.93	**49.59**	**0.85**
	31.24	6.99	31.26	6.95	36.39	3.87	55.46	0.43	**67.75**	**0.10**
	32.64	5.95	32.66	5.9	38.06	3.19	57.46	0.34	**58.04**	**0.32**

	33.67	5.28	33.69	5.26	39.25	2.78	53.46	0.54	**53.73**	**0.53**
	32.76	5.87	32.86	5.84	38.37	3.08	51.47	0.68	**65.47**	**0.14**

6. CONCLUSION

Identifying the noise type is the first phase in image processing for de-noising. Once the type of noise is identified respective filters can be applied for de-noising, so it enhances the image quality and helps in future steps of image processing. In this study, it is found that the infrared images will contain the impulse noise. So to remove impulse noise from infrared images, Non linear filters such as median filter, relaxed median filter, adaptive median filter, decision based median filter and untrimmed decision based median filter are used. However, the major drawback of standard median filter is that the filter is effective only at low noise densities. To overcome this drawback different types of median filters such as relaxed median filter, adaptive median filter, decision based median filter, untrimmed decision based median filter are considered. Untrimmed decision based median filter algorithm is effective for salt and pepper noise removal in images at high noise densities are evaluated with PSNR and MSE. From the results it is identified that untrimmed decision based median filter gives higher PSNR values and reduces the MSE values.

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