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Snowfall Noise Elimination Using Movement Information and Similarity Pixel Information

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ABSTRACT

In recent years, the monitoring regardless of the use of indoor or outdoor is easily realized by the rising of the performance of the surveillance camera. Since the monitoring for the outdoors cannot ignore the influence of the disturbance caused by the weather. Therefore, the methods for noise elimination by using the filters and the methods for noise elimination by using the displacement were proposed. However, the former cannot deal with heavy snowfall, and the latter cannot do real time processing. This paper proposes a method to eliminate the snowfall noise in images of surveillance camera by using movement information and similarity pixel information. Processing of this method is closer to a real time processing than the conventional method, and can eliminate the heavy snowfall noise in images of surveillance camera. The effectiveness of the proposal method was confirmed by an experiment using a real snowfall movie and prototype snowfall apparatus.

1. INTRODUCTION

The monitoring for various purpose has become easy due to the rising at performance of surveillance camera. Usually, a surveillance personnel looks at the monitor of a surveillance camera. However, the surveillance personnel can find nothing when the heavy snow falls. If this system has been used for monitoring a crossing gate of railroad, it will lead to an accident. For the outdoor monitoring, a weather disturbance cannot be ignored. So, several methods to remove the noise such as snow in a surveillance camera have been proposed. For example "The Method of Removing Noise by Using A Filter"[1], "Snowfall Noise Elimination Using a Time Median Filter"[2], "Realtime Snowflake Elimination Adaptive to Snowfall Situations"[3] and "A Method of Removing Noise Using Slippage"[4] are proposed. In the first method, the noise in the image is removed by using filters such as median value filter and average value filter. However, when there are a lot of snow noises in the image, this method is not valid. When the snow noise occupies more than half of the filter area, the whole image after processing will become white. In the second method, a median filter is applied on the time axis. In this method, the number of frames used for one time processing by using a filter is changed according to the amount of snow to do processing for an image with a lot of snow noises. However, In the case of a heavy snowfall, a lot of soiling by rubbing occurs by increasing the number of frames. The third method calculates each slippage using a plurality of adjacent frames. The noise parts can be detected as a value by taking a difference using the slippage. The noise can be eliminated by a filling processing by using a part of same place of another frame. This method can eliminate snow noise cleanly for a small snow. However, if there are many snow noises in the image got from surveillance camera, many similar pixels exist in the image. So, in this case, this method cannot calculate the slippage correctly. This paper proposes a method of removing snowfall noise using movement information and similarity pixel information. The snow noise is removed based on the move information of the move object in an image of a surveillance camera. First, move information is extracted by the difference processing using contiguity frames. Next, the snowfall noise portion is distinguished using the extracted move information, and is removed. However, the pixels that are not the part of snow but are similar to the part of snow will be disappeared by this processing. In order to prevent erroneous processing, consider pixels similar to snow and snow. Pixels similar to snow are likely to stay long on the spot. Conversely, one snow grain never stays in the same pixel continuously [3][5]. Therefore, we added a judgment with not only the similar pixel between contiguity frames but the amount of change of HSV value of the pixels. In order to confirm the effectiveness of the proposal method, we experimented with real snowfall videos and an equipment generating imitation snow. Based on the experimental results, the effectiveness that snowfall noises can be removed without the soiling by rubbing was confirmed.

2. PROPOSAL METHOD

Figure 1 shows the processing of the proposal method.

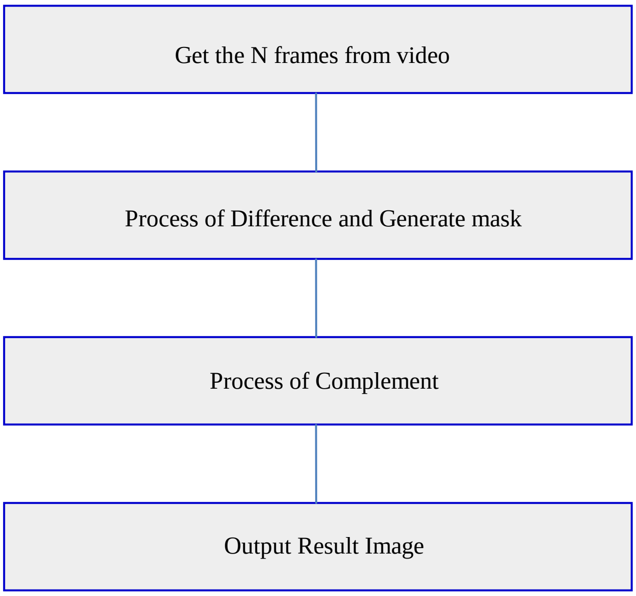

Figure 1: Flow chart

In order to identify snow pixels, pixels that moved between frames are extracted. In this stage, the movement information is extracted by difference processing, and a mask masking the portion without snowfall noises is generated by using this movement information. In this paper, in order to evaluate whether or not an object in the image is moving, the difference value of the pixel value of each corresponding pixel between frames is defined as movement information. Movement information includes movement of snow and movement of other objects. Among them, the RGB values of snow are close to 255(The maximum value). Therefore, the amount of change when changing from a pixel that is not snow to snow increases. However, there are cases where the amount of change is small. A small amount of change means that consecutive pixels do not change much. The shielding property of snow is considered to be low for pixels with small variation. Therefore, by acquiring a pixel having a large change amount, movement information of snow with high shielding property can be obtained. Based on the obtained movement information, mask images are generated to distinguish them from pixels that are not snow and pixels that are snow. Pixels except the snow are chosen using a formed mask. And, for each pixel position in the image, the pixel with the smallest pixel value is picked out from the chosen pixel, and the snow noise in the image from a surveillance camera is filled by using the pixel picked out. However, the pixels similar to snowfall noises on the image may be erased. We used the similar pixel information between adjacent frames to prevent it.

2.1 Generate the Mask

The moved pixels between adjacent frames are obtained by getting the difference portion from each adjacent frame. The mask image is generated by calculating the difference between the RGB values of each pixel of adjacent frames. The equation(1) is an equation to calculate the difference between the RGB values of each pixel.

$$
\begin{aligned}
A(r) - B(r) &= S(r) \\
A(g) - B(g) &= S(g) \quad \ldots\ldots\ldots(1) \\
A(b) - B(b) &= S(b)
\end{aligned}
$$

In the equation, r, g, b are the R, G, B pixel values of each pixel respectively. A is the frame of interest, B is the adjacent frame, and S is the difference value between A and B. The color of pixels of snowfall noise is basically near the white color. So, the RGB value of each pixel of the snowfall noise can be defined as 255. For this reason, the difference value about the movement of snow obtained by equation(1) is almost a positive value. In the following cases, there is a possibility that a difference value about the movement of snow becomes negative value.

a.

When a heavy snow falls, the snowfall noises are overlapped within multiple frames.

b.

The difference value changes finely due to various influences such as environment light change.

c.

The RGB values of snow grains between the frames change minutely.

Since the difference value is a negative value in the case of a, b or c, in order to judge snowfall noise with threshold values, the threshold values of the RGB obtained by experience are set by positive value. If the difference value of pixel exceeds the threshold, this pixel is defined as a pixel of snow. By above process, a binary mask image is made to avoid processing at the portion without snowfall noise. The threshold is decided by the amount of change of the pixel except the snow. Think about the possibility that pixels similar to snow are processed erroneously. When pixels of objects similar to snow exist, it is difficult to distinguish them from snow. Therefore, restrictions by features of pixels resembling snow are set in this processing. There is a possibility that it stay in multiple frames in pixels other than snow, but snow does not stay in multiple frames on the same pixel. Therefore, a pixel holding a similar pixel value between adjacent frames is not snow experimentally.

2.2.Complement

N-1 mask images are generated using N frame images. At first, the first frame S_0 is defined as a frame to be complemented and the other frames S_n are defined as frames to be used for complement. Each pixel of S_0 is checked one by one and the entire image of S_0 is complemented. In the mask image generated by the difference processing, the moved pixels are shown by 255 (maximum value) and the pixels that did not move are shown 0 (minimum value). Therefore, the pixels that did not move are used for complement. The pixels that have not moved are selected from the N-1 frames based on the mask images. Then, the pixels with the lowest value of RGB are selected. Snowfall noises are removed by complement processing with the selected pixels. By using S_n for all pixels of S_0, all snowfall noises in S_0 are removed.

3. Experimental and Discussion

In order to confirm the availability of the proposal method. In determining the difference threshold, the threshold value was determined by an experiment. A graph comparing the removal rate of snow in the image with the threshold at that time is shown in the figure. The snow in the image is not possible to express by numerical values, the threshold was determined based on visual evaluation. Evaluation is carried out in 5 stages and evaluation criteria are shown in the table 1.

Table 1: Evaluation's stages

	Removal rate	Soiling by rubbing rate
1	Snow has not been removed	There is a big delay in the video
2	Snow has been removed a little	There is a delay in the video
3	The snow has removed moderately	There is a little delay in the video
4	Snow has been almost removed	There is almost no delay in the video
5	Snow has been removed	There is no delay in the video

The removal rate means the amount of snow noise removed from the original image. Soiling by rubbing rate means how far the moving object is behind the original image. The evaluation was carried out with the above. The evaluation results are shown in the graph of the figure 2.

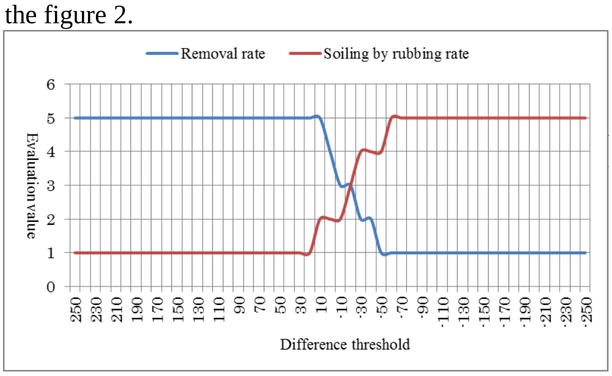

Figure 2: The evaluation results

Figure 3: Original Image

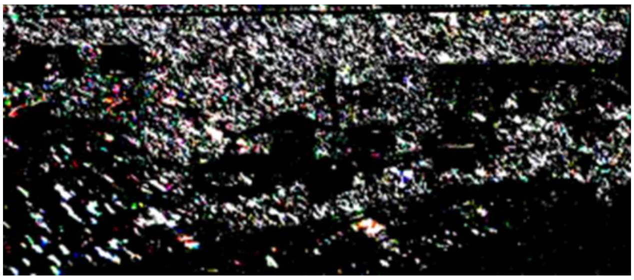

Figure 4: Mask Image

Figure 3 shows the images obtained from the Internet with resolution 1280 * 720, fps 29. We used this video because it is easy to acquire the movement amount of snow because it is the image by the fixed point camera. Fig. 4 shows the mask image generated by the mask generation processing. In Fig. 4, it can be seen that each RGB value is represented by the maximum value of 255. As a result, it can be seen that the pixel where snow is moving can be acquired. An object not moving was not detected by setting the difference threshold value high as 10. Moreover, it can be seen that fine snow is also generated as a mask image in a lot of snow part. Therefore, in this process, it can be seen that it is possible to distinguish between a moving object and an object not being moved.

3.2 Complement

This stage shows complement result.

Figure 5: Result Image

Figure 6: Enlarged Image

Fig.5 shows the original image and the processed image. Fig.6 is the elements on larger scale of Fig. 5, and it can confirm that snowfall noises are removed. The experimental result showed that the snowfall noises in the image can be complemented with the proposal method. The people in the left side of the original image of the video who are hard to see became visible clearly.

3.3 Problem and Resolution

The snowfall video used in this experiment is snowstorm video with one direction snowstorm. So we made an experimental system to obtain snowstorm from multiple direction and photographed pseudo snowflakes movies. In Experiment 2, we confirmed that the proposal method is effective for blizzard from various directions by using the pseudo snowflakes movies.

3.4 Experimental Apparatus

In Experiment 2, to create snowfall video in various conditions an experimental system was made. The system for movie photographing is created using iron framework like box. In the lower row, cardboard was used for wind input. In the upper row, we made the wall using wrap. In the experimental system, pseudo snow circulates in the space partitioned by wrap. A vacuum cleaner and the electric fan are used for ventilating. The snowy grains were made of polystyrene foam bead material. In order to reproduce the motion like snow, based on the air volume of the air blower, the 5 mm bead was used. By making the wall of the upper part wrap, it is possible to penetrate the background. Therefore, it is possible to record an image like an actual surveillance camera. The video for experiment was a video that a person is walking through the back of the experimental instrument.

The environment when capturing the experiment video is as follows.

· Shooting was done indoors
· There was an air-conditioned environment
· There was outside light but blocked by blinds
· There is a fluorescent lamp on the upper part of the experimental equipment, and the light is illuminated by the fluorescent lamp.
· Fluorescent lamps are 36 watt and two are attached.

3.5 2nd Experimental

We decided to confirm the items similar to the previous experiment, and the difference result, then confirmed the supplement result.

Figure 7: Difference Image

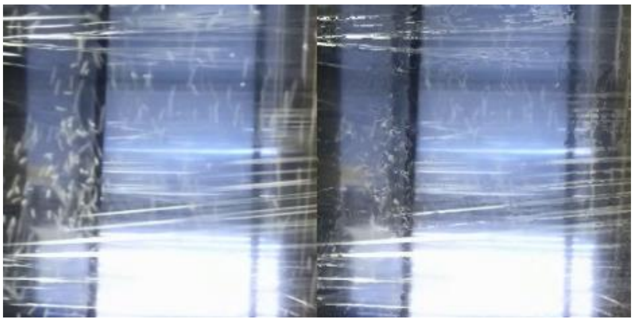

Figure 8: Enlarged Result Image

Fig. 7 shows a mask image similarly to Experiment 1. It can be seen that the movement information is shown by the maximum value of each RGB value. Fig. 8 shows the original image on the left and the result image on the right. It is understood from the result image on the right that the snow is supplemented and the image become easy to see. We can confirm that the person who walks through the back of the experimental instrument became clearer since the snowfall noises in the image are complemented. Therefore, the proposal method is effective even if a snowstorm come from various directions.

3.6 Consideration

To discuss the effectiveness, the proposal method was compared with the conventional methods. The discussion points are shown below.

a. The result image becomes white when noises are removed.
b. The soiling by rubbing occurs in the result video when removing the snowfall noises in images.
c. It is not possible to cope with a lot of snow.

About the problem a

In the conventional methods, when the noises are removed using filter, if many noises are contained in a pixel group which a filter is applied, noises will affect the result. However, in the processing of the proposal method, the influence due to the noises is small. This is because the proposal method selects pixels from the group of pixels to do filtering.

About the problem b

In the conventional method, the problem is that the number of frames is variable. When using many frames, the move portion in the image to complement and the portion for the complement may not be the same portions. The proposal method has this problem also. However, the experiment using a same video showed that the processing time of the conventional method is 1 to 2 seconds but the processing time of the proposal method is only at most 0.23 second. So the proposal method is more superior.

About problem c

By the conventional method, in the case of heavy snow, it is difficult to discover the portion which corresponds to contiguity frames, so the conventional method is inapplicable to heavy snow. Because a matching processing of portions is used between contiguity frames, the snow detection was not possible when a heavy snow falls. However, the proposal method does not use the matching, so the snow can be detected even if a heavy snow falls. The image taken using the experiment system had many portions which were alike in the background. Since the object imitated in snow is only floating, there are many similar portions. The proposal method can remove snow even in scenes with many similar pixels.

Regarding processing time

Currently, it takes about (0.9 s) in the proposal method to process one frame. Therefore, the processing speed is about 11 fps. For processing, CPU with 8 cores is used. We think that processing can be speeded up by hardware for high-speed processing called GPU. Although GPUs have various core numbers, some of them are high and some have 2000 cores. Therefore, the processing speed is calculated by 2000 cores. By changing the process using 8 cores to 2000 cores, it seems that the number of cores will be about 250 times and the speed will be improved. We think that real-time processing is also possible.

4 CONCLUSIONS

In this paper, we propose a noise elimination method using movement information and similar pixel information between adjacent frames, and constructed a snow removal system applicable to monitoring camera in snow country. In the proposal method, movement information is extracted by a difference processing. About the frame for noise removal, the pixels which have the minimum pixel value from the correspondence pixels in the other N-1-frame images are elected, and the noise is removed by the complement by using the elected pixels. However, by this process, not only snow but also the pixels with values near snow are deleted by the processing. To avoid this problem, a positive value is used as a threshold value in the difference processing. In order to confirm the effectiveness of the proposal method, an experiment was conducted by applying processing to the actual video image. We confirmed that the snowfall noises were removed by the proposal method. Therefore, the effectiveness of the proposal method was confirmed by the experimental results. In the conventional method, there was also snow which could not be completely processed in the case of a lot of snow. However, we confirmed that snow was cleanly removed by the proposal method. We also thought that processing time can be done in real time by using GPU.

5. REFERENCES

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