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SNOWFALL NOISE ELIMINATION USING THE CONVEX HULL-TYPE MOVING OBJECT SYNTHESIS METHOD

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ABSTRACT

In recent years, the use of surveillance cameras is increasingly recommended and they have been installed in many places. Snowy conditions at the time of an accident were associated with the problem that cars and accident circumstances become difficult to discern in images shot during snowfall. Previous techniques proposed methods for elimination of noise caused by snow using image shift or dedicated filters for the elimination of snowfall in video. However, these are associated with issues such as inability to cope with heavy snowfall or moving objects fading from view or being hard to discern. The present study proposes a method for snowfall noise elimination by extracting moving objects using the travel and the size of the moving object region between continuous frames, shaping a moving object using a convex hull algorithm, and compositing images while using the difference mask image excluding the moving object area. By distinguishing between falling snow and other moving objects, we can prevent objects other than snowfall becoming invisible. In addition, the convex hull can prevent to get out of shape of moving objects other than snowfall. In order to confirm the effectiveness of the proposed method by experiments, we used a video in which cars actually run in a snowfall environment. As shown in the experimental results, it can be confirmed that the snow grains are removed and the shapes of the cars in the image are kept well.

Keywords: noise elimination, snowfall noise elimination, different, snowfall, convex hull.

1. INTRODUCTION

Large numbers of surveillance cameras have been installed in recent years in a variety of locations [1]. For instance, they are widely used to monitor conditions and incidents on highways or roads with low numbers of people present [2]. However, in snowy regions surveillance camera images are indistinct due to the effect of snowfall making the circumstances of traffic incidents for instance difficult to ascertain [3]. To that end, various techniques have been proposed to eliminate snowfall in images and make other moving objects more distinctly visible.

Methods proposed include “A method of removing noise by using a Filter” [4], “Snowfall noise elimination using a time median filter” [5], “Real-time snowflake elimination adaptive to snowfall situations” [6]. The first method uses filters such as median and mean filters to eliminate snowflake noise in images. However, since the median value is the noise value when snowflake noise takes up over half the filter area, noise cannot be eliminated. The second method applies a median filter onto a time axis. Snowflake noise is eliminated by altering the number of frames for median filtering in accordance with the amount of snowfall. In other words, the method requires a high number of frames at times of heavy snowfall. Accordingly, pixels are replaced from many images resulting in image distortion. The third method eliminates snowflake noise in images using discrepancies in noise calculated from multiple neighboring frames. However, if images obtained from surveillance cameras contain a lot of snow flake noise, the number of similar pixels in the images is high. Accordingly, the amount of discrepancy cannot be calculated accurately and noise can therefore not be eliminated.

To solve the problems with the previous methods, we focused on the clipping of moving objects and proposed a snowfall removal method that stuck only the moving objects to the background image, thereby solving the problem of missing moving objects [7]. However, it can be applied to a large moving object by pasting it on the background image, but it cannot cope with small changes such as a small moving object. In the present paper, the moving object is removed from the difference image including all moving objects using the moving object extraction image. After that, by interpolating and synthesizing only the snowfall part with the background image, it was possible to handle both missing moving objects and fine moving objects. By distinguishing between falling snow and other moving objects, we can prevent objects other than snowfall becoming invisible. In addition, the convex hull can prevent to get out of shape of moving objects other than snowfall. Then, by interpolating only necessary portions from the background image, it is possible to leave a fine and fine moving object or change. To confirm usefulness of the proposed method, experiments were conducted using video of actual driving vehicles during snowfall.

2. PROPOSED METHOD

Figure-1 is the flow chart for the proposed method, with each box containing a description of the processing step.

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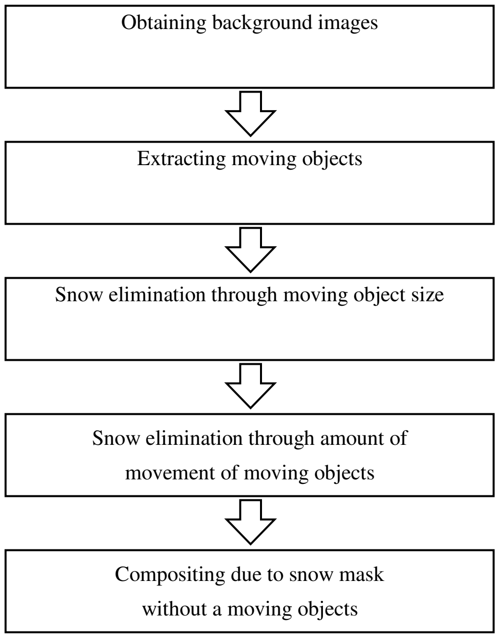

Figure-1. Flow chart of the proposed method.

2.1 Background Image Generation using Continuous Frames

Surveillance cameras record continuingly and video therefore changes greatly with the changes in sunlight depending on whether it is day or night. These changes must be dealt with when acquiring background images. Therefore, this method extracts the background image using the movie from the current frame to the frame several seconds before.

For pixels of interest that have a moving object in it, specific pixels will change while the moving object is passing through and will become background once the object has passed through in the continuing shot. Therefore, pixel values where a static object is present multiple times are emphasized strongly by selecting the mode value of pixel values in time series. In this way, background images without any moving objects are generated. Figure-2 illustrates the example of background image generation: the left image is the frame image, and the image on the right is the background image generation result.

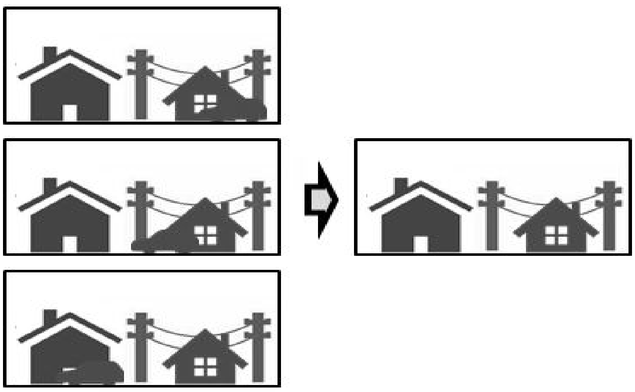

Figure-2. Example of generate background image.

2.2 Extraction of Moving Objects by Difference Processing

It is possible to extract just the moving object that is not contained in the background image by obtaining the difference between the frame image and the generated background image. Figure-3 illustrates the example of extraction of the moving object: the top left image is the background image, the bottom left is the target frame, and the image on the right is the resulting image of the extracted moving object.

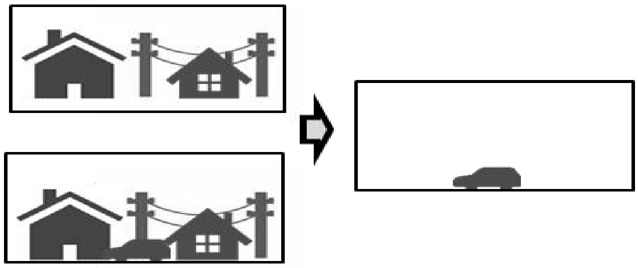

Figure-3. Example of extraction of moving object.

2.3 Snow Removal by Size of Moving Object

The image obtained by extracting moving objects contains, apart from the vehicle, large and small snowflakes. As shown in Figure-4, snowflake size when shot by a permanently installed surveillance camera is large when snowflakes are recorded in the vicinity of the camera, and. small when they are shot at a distance from the camera. The top image is a side view, and the bottom image illustrates what an image looks like when shot by an actual surveillance camera.

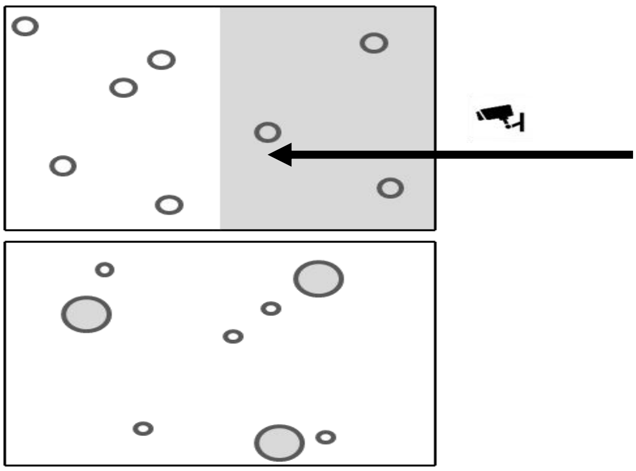

Figure-4. Illustration of image when recorded by actual surveillance camera.

In this proposal, the removal process is performed according to the size of snowflakes. Small snow particles in the area far from the camera are removed by the Opening process [8], which is one of the morphological operations. Opening processing is a combination of shrinkage processing that reduces pixels around the pixel of interest and dilation processing that

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increases pixels around the pixel of interest. The top row in Figure-5 shows processing using small pixel blocks and the bottom row shows processing for large pixel blocks.

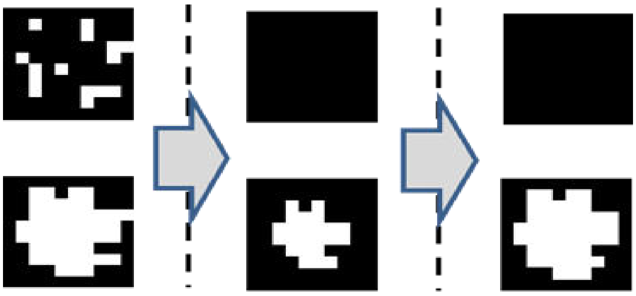

Figure-5. Example of opening processing.

Further, there is a window glass at the center of the car, and a road or another background is reflected on the window glass, so that there is an area that cannot be detected as a moving object in the difference area. Therefore, the extraction range of the moving object is set so as to surround the entire vehicle using the convex hull algorithm. An example in which the window glass could not be detected in the difference area of the car is shown in Figure-6. As shown in Figure-6, since the entire vehicle is covered by the convex hull algorithm, the problem that the moving object is get out of shape can be solved.

Figuree-6. Example of opening processing.

2.4 Snow Removal by Amount of Movement of Moving Object

Since no distinction can be made between large snowflakes near the camera and vehicles based on size, this is done based on the velocity (amount of movement) of the moving object. Large snowflakes constitute snow that is close to the camera, and since these are far nearer the camera than the vehicle, their travel is relatively larger. Based on this, we know that travel of snowflakes near the camera and of the vehicle differs. If a moving object extracted from continuous frames moves at a speed below a specific travel value it is judged to be a vehicle, if speed exceeds the specific travel value it is judged to be snow. Figure-7 illustrates the travel of snow and vehicle. Figure-8 shows an example in which the overlapping state of pixels in the movement of a car and snow is enlarged and displayed.

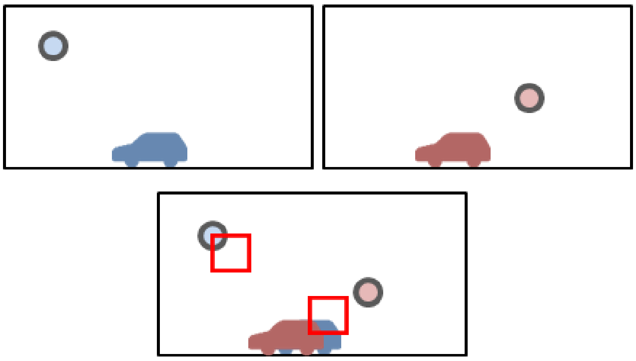

Figure-7. Vehicle and snowflake movement.

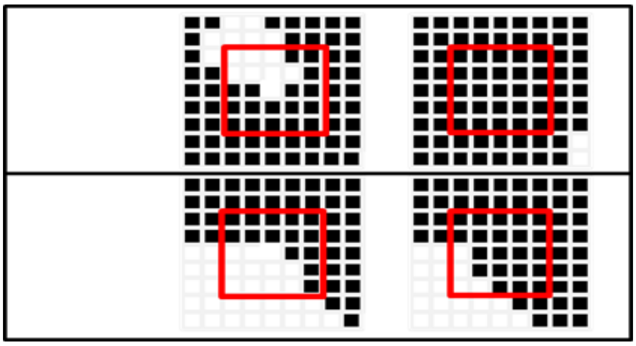

Figure-8. Judge with each movement amount.

2.5 Moving Object Compositing due to Snow Mask Without a Moving Objects

The extracted moving objects ultimately obtained are moving objects other than snow, such as vehicles. Using the mask from which moving objects are extracted, the area of moving objects is removed from the mask image obtained by difference processing. Therefore, since the moving object is not present in generated background images, images without snow can be generated by complementing and synthesizing pixels from the background image using a mask other than the moving object. The flow of the proposed synthesis method is illustrated in Figure-9.

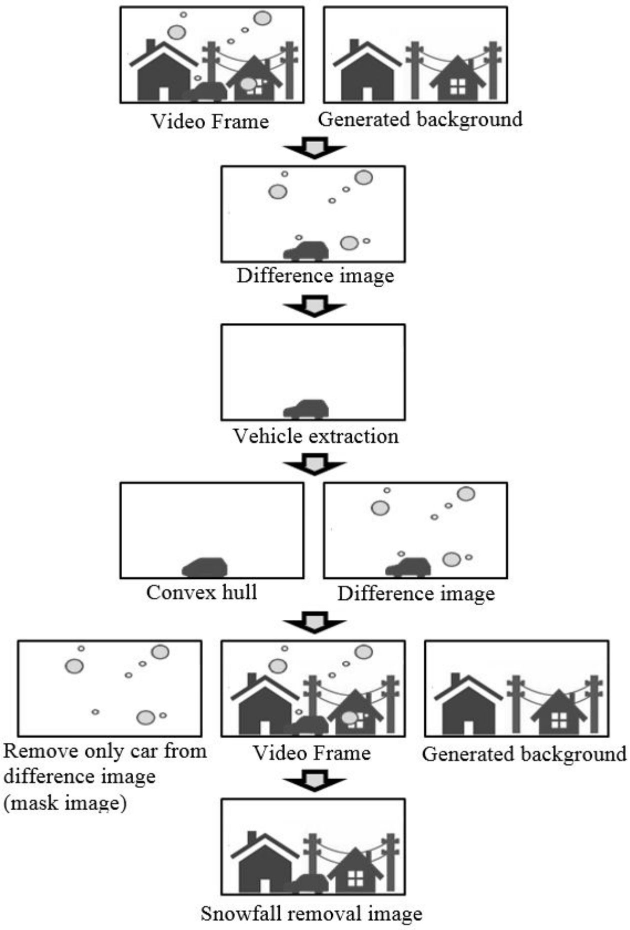

Figure-9. Flow of the proposed synthesis method - Example.

3. EXPERIMENTS AND RESULTS

To confirm the usefulness of the proposed method, we conducted experiments using images of vehicles driving during snowfall. We performed three experiments for this study to confirm usefulness in a variety of environments. Snow removal is performed on each snowfall video using the proposed method. The result image shows a part of the video enlarged to make it easier to see the removed location.

Table-1. Experimental image details.

Experiment	Road type	FPS	Resolution
Exp. 1	Highway	29	720*480
Exp. 2	Local road	29	1280*720
Exp. 3	Alleyway	29	1920*1080

3.1 Experiment I

The images used in this experiment are of vehicles on the highway driving from the front in the picture away to the left. Since there are few obstacles on highways it is the type of road where vehicles are most likely to driving at speed. Figure-10 shows the experimental results. Figure-10(a) is the original image, Figure-10(b) is the generated background image, Fig. 10(c) is the image of the extracted moving objects, Figure-10(d) is the image of the difference mask excluding moving objects, and Figure-10(e) the resulting image. Figure-11 shows an enlarged image of the vehicle part of the original image and the result image.

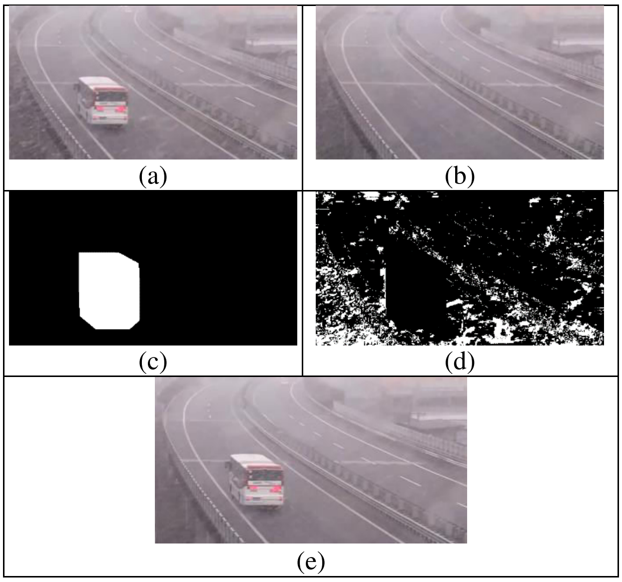

Figure-10. Result 1 of experiment 1.

Figure-11. Result 1 of experiment 1 (Enlarged view).

The resulting image clearly shows that, compared to the original image, the snow has been eliminated and visibility is better. Furthermore, it is clear that, in terms of the problem of moving objects such as vehicles fading, the entire shape of the car has been preserved.

In addition, a processing result in a scene where a plurality of cars go is shown in Figure-12. Figure-12(a) is the original image, Figure-12(b) is the generated background image, Figure-12(c) is the image of the extracted moving objects, Figure-12(d) is the image of the difference mask excluding moving objects, and Figure-12(e) the resulting image.

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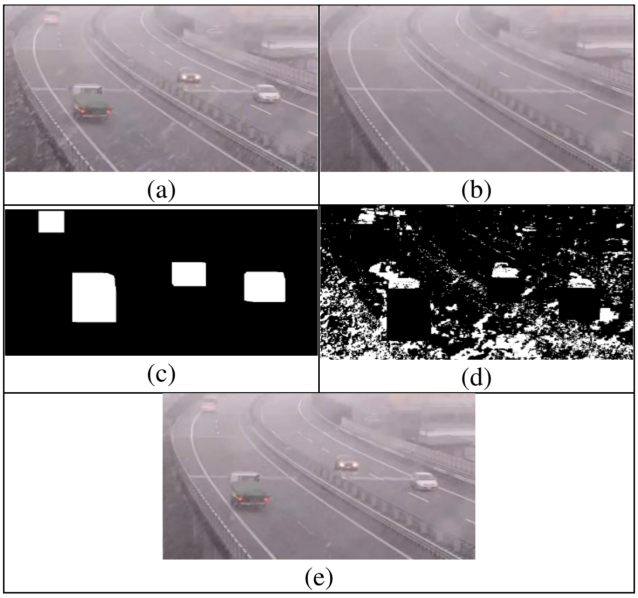

Figure-12. Result 1 of experiment 1.

Even in a scene with multiple moving objects, it can be seen that the fine snow in the original image is removed, making it easier to grasp the road information.

3.2 Experiment II

The images used in this experiment were taken on a local road. Different from Experiment I, speed on local roads is low. Moreover, whereas the line of travel in the image for Experiment I was almost vertical, in these images direction of travel is from right to left. Results are shown in Figure-13, with Figure-13(a) is the original image, Figure-13(b) is the generated background image, Figure-13(c) is the image of the extracted moving objects, Figure-13(d) is the image of the difference mask excluding moving objects, and Figure-13(e) the resulting image. Figure-14 shows an enlarged image of the vehicle part of the original image and the result image.

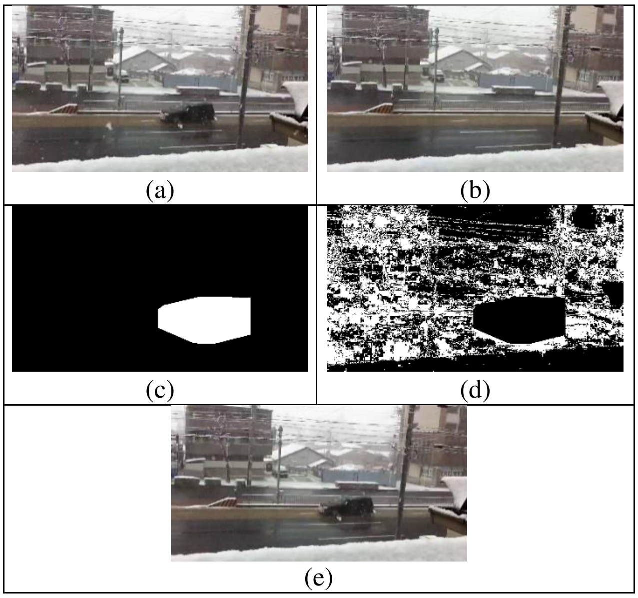

Figure-13. Result of experiment 2.

Figure-14. Result of experiment 2 (Enlarged view).

The resulting image shows that snow can be eliminated while still preserving the shape of a vehicle driving in a horizontal direction.

3.3 Experiment III

The images used in this experiment are of an alleyway with few people passing through. Velocity of cars passing through a narrow alleyway is even lower than in Experiment II. Results are shown in Figure-15, with Figure-15(a) is the original image, Figure-15(b) is the generated background image, Figure-15(c) is the image of the extracted moving objects, Figure-15(d) is the image of the difference mask excluding moving objects, and Figure-15(e) the resulting image. Figure-16 shows an enlarged image of the vehicle part of the original and result images.

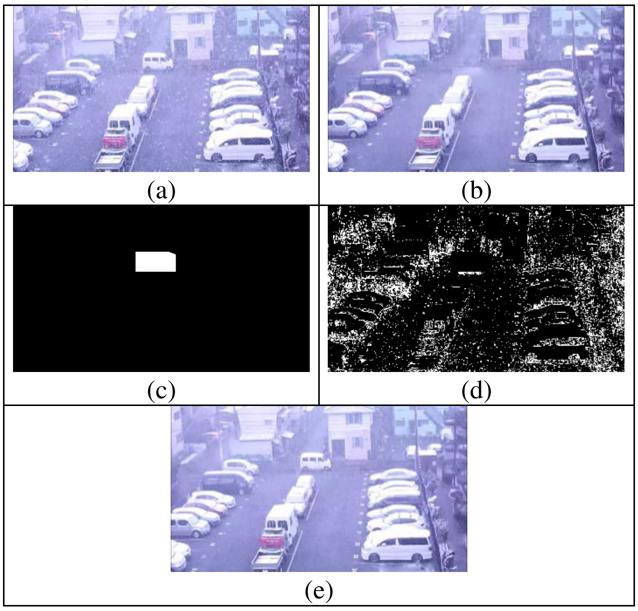

Figure-15. Result of experiment 3.

Figure-16. Result of experiment 3 (Enlarged view).

The resulting image shows that despite the complex environment containing buildings and utility poles, snow details have been eliminated and road information can be easily ascertained.

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4. DISCUSSIONS

Based on the experimental results, we were able to confirm that snow can be eliminated for various environments. Moreover, regarding the problem with previous methods where small snow details remained, we confirmed that they can be eliminated through opening processing. It was also confirmed that white numbers or white lines on the road surface which are similar to white snowflakes do not fade and that numbers can be clearly ascertained. Figure 17 shows a comparison between input frame and processed results.

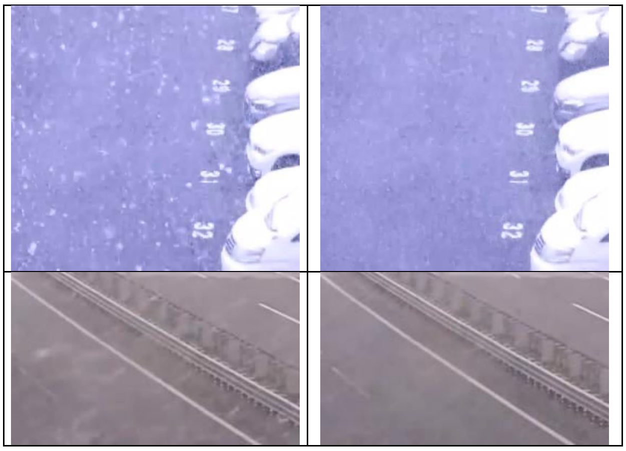

Figure-17. Results of removing small snow grains.

It can be removed because a background image without moving objects is created from the current frame to a few seconds ago, and it is confirmed that fine snow can also be removed by size of moving object using morphological method. The result of snow removal by size of moving object using the morphological method is shown below as Figure-18.

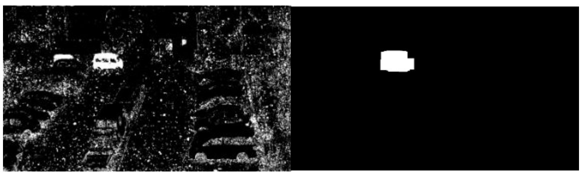

Figure-18. The result of snow removal by size of moving object using the morphological method.

In relation to moving objects, it was confirmed that moving objects alone could be accurately extracted from the subtraction image using the convex hull algorithm. The result of interpolation of the moving object using the convex hull algorithm is shown in Figure-19 below. Figure-19 shows a comparison between the input frame and the processed results. It was confirmed that the shape of the vehicle could be clearly seen.

Figure-19. Interpolation result of moving object using convex hull algorithm.

Based on the above, it was confirmed that the proposed method solved the "problems where fine snow remained" and "problems in which the moving object get out of shape by reflection of the window glass of the moving object", which were the conventional problems.

Furthermore, the proposed method solves the problem of small moving objects disappearing because a moving object is not synthesized to the background image. Fig. 20 shows an enlarged view of the periphery of a small moving object based on the result of Experiment 1. Since the background image uses several frames before the input video, a moving object or the like that does not exist in the current input video may be reflected. As a result, when only a moving object is synthesized on the background image, there is a problem that a moving object that does not exist in the input video is reflected. However, in the snow removal result of the proposed method, only a snowfall part is interpolated from the background image, so it is possible to hold a small moving object.

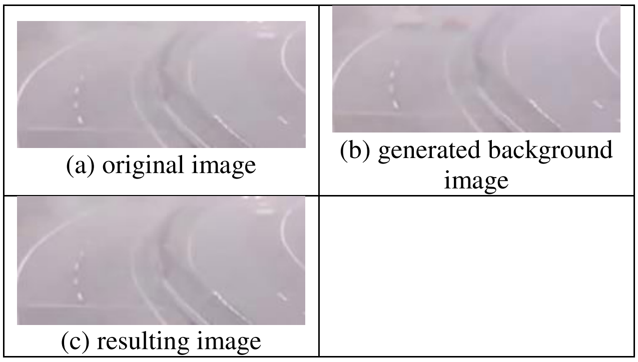

Figure-20. Comparison on the problem of small moving objects disappearing.

5. CONCLUSIONS

In this study, we focused on the clipping of moving objects and proposed a snowfall removal method that stuck only the moving objects to the background image, thereby solving the problem of missing moving objects [7]. Later, this paper was proposed as a new method that included small changes that could not be accommodated by background composition. In this study, the moving object is captured by the method of the previous report [7], the moving object is shaped using the convex hull algorithm, and the moving object is removed from the difference image. Then, a snowfall noise removal method was proposed by extracting and interpolating only snowfall. To confirm usefulness of the proposed method, processing was applied in experiments with images taken in various environments including a local road, highway, etc. Results confirmed that the proposed method is useful in any environment, independently from the size or velocity of monitored objects, that is vehicles. Previous methods were associated with the problem that moving objects get out of shape and became difficult to discern when snow was eliminated. But as a result of the proposed method, it was confirmed that moving objects do not fade and that their shape is preserved.

REFERENCES

[1] Yano K. and Kawai T. 2016. Technology Trend of Image Recognition for Surveillance Camera. Journal of the Imaging Society of Japan, 55(3): 341-347, DOI: 10.11370/isj.55.341.

[2] Kubo N. and Mori M. 2011. Detailed Analysis on Traffic Accidents Using Drive Video Recorder. Transactions of the Japan Society of Mechanical Engineers Series C, 77(779): 2940-2952, DOI: 10.1299/kikaic.77.2940.

[3] Andreescu1 M. and Frost D. B. 1998. Weather and traffic accidents in Montreal, Canada. Climate Research. 9(3): 225-230, DOI: 10.3354/cr009225

[4] Sato J. 2011. Image Processing Apparatus, Method, Program, and Imaging System. Japanese Unexamined Patent Application Publication, No: 2011-142548.

[5] Miyake K. and Yoneda M. 2001. Snowfall Noise Elimination Using a Time Median Filter. Journal of the Institute of Image Electronics Engineers of Japan, 30(3): 251-259, DOI: 10.11371/iieej.30.251.

[6] Miyake K. and Yoneda M. 2003. Real time Snowflake Elimination Adaptive to Snowfall Situations. Journal of the Institute of Image Electronics Engineers of Japan, 32(4): 478-482, DOI: 10.11371/iieej.32.478.

[7] Sato Y., Kokubo K and Bao Y. 2019. A snowfall noise elimination using moving object compositing method adaptable to natural boundary. Electronic Imaging, Image Processing: Algorithms and Systems XVII, pp. 251-1-251-6, DOI: 10.2352/ISSN.2470-1173.2019.11.IPAS-251.

[8] Haralick R. M., Sternberg S. R. and Zhuang X. 2003. Image Analysis Using Mathematical Morphology. IEEE Transactions on Pattern Analysis and Machine Intelligence, 9(4): 532-550, 1987, DOI: 10.1109/ TPAMI.1987.4767941