Survey for reduce the burden on snow removal work

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ABSTRACT

In Japan, elderly society is progressed and the number of workers in construction industry have been decreased likewise in many other industries. As snow fall area are occupied about 1/3 in Japan, the situation of lack of workforce especially serious in these snowy regions. In addition, many kinds of special skills are required for operators of snow removal because of a characteristic of Japan's road environment such as existing many narrow roads and obstacles.

In order to identify current problems, a survey was conducted on snow removal operations at Nagaoka University of Technology. The reason for targeting snow removal operations at Nagaoka University of Technology was that the amount of snowfall was expected to be large, and modelling of the work situation was expected to be easy. A drive recorder was installed in the vehicle to film the operator of the rotary snowplow, and several days of snow removal work during snowfall were recorded. In addition, we interviewed the operators about problems, requests, and key points of operation. The work data for analysis was the recorded data from 6:50 to 7:20 on January 8.

This hearing result said rotary snow removal machine operator worry about damage to road ancillary equipment and to occur snow jam of shooter. If snow jam of shooter occurs, the rotary snow removal machine operator must get out of the cockpit and use a shovel and his hands to remove the snow jam from the shooter. It was commented when that ride on and off and removal of snow jam was burden on snow removal worker. The snow removal crew commented that getting in and out of those snow removal machine and removing snow jams was burdensome.

The result of the rotary snow plow operator motion was record by the drive recorder shows 4 sections operator's motions of snow removal work.

The first section is Moving and Previewing. While moving from one snow removal area to the next, the operator looks at snowfall conditions and determines the need for snow removal operations. In this survey Moving and Previewing section accounted for 57% of snow removal work, making it the most time-consuming part of the snow removal process.

The second section is Remove snow jam in the shooter of the rotary snowplow. This section is accounted for 31% of snow removal work in this survey. The shooter is a cylindrical structure that controls the direction in which snow is thrown. In addition, actions that supported the hearing comments included getting out of the driver's seat of the rotary snowplow to remove snow, as well as tapping the ground with the auger case to remove snow jams while in the driver's seat.

The third section is snow removal work. The snow removal operations are conducted to move snow that obstructs traffic on the university campus to other locations. This is essentially the expected use of rotary snowplows, and this task should account for a large percentage of the total work, but in this survey, it only accounted for 6% of the total work time.

The fourth section is parking. This section is park the rotary snowplow to carport. This task accounted for 4% of the total worktime.

In this survey, it was found that a disproportionately large amount of the work done by rotary snowplow operators involved removing snow jam in the shooter of the rotary snowplow, compared to the time spent snow removal work. Based on the results of the hearings, we guess that these events are caused by the aging of the rotary snowplow trucks and the snow being moistened by the snow-melting pipe, which makes it easier for snow to stick to the surface of the shooter. The results of the posture estimation revealed that operators lean forward when the shooter is clogged with snow in order to see what is going on. These results suggest that operators may feel fatigue due to their posture collapsing, in addition to the task of getting out of the cab and clearing snow from the chute. I assume it is possible.

1 INTRODUCTION

In Japan, elderly society is progressed and the number of workers in construction industry have been decreased likewise in many other industries. As snow fall area are occupied about 1/3 in Japan, the situation of lack of workforce especially serious in these snowy regions. In addition, many kinds of special skills are required for operators of snow removal because of a characteristic of Japan's road environment such as existing many narrow roads and obstacles. Such like signs, curbs, snow poles, guardrail, etc. If they are damaged during work, the contractor must bear the repair costs.

Finland has put a lot of effort on digitalization in government period 2015-19 [1].

Digitalization development is still going on, but the development volume is lower than in 2015-19 and the emphasis is on information systems. there are also some developments for examples contructor's maintenance process digialization, where information transmits in two directions to all maintenance parties.

There are still going many test pilots about fleet-based information systems, which produce continuous weather, slippery, friction snow inforation on the road.

Road snow removal in Japan is carried out using rotary snowplows, motor graders, snow removal trucks, snow removal dozers, antifreeze spraying vehicles, etc.In addition to snow removal machines, snow removal pipes are installed on roads in areas where groundwater can be utilized, and the water from the nozzles of the snow removal pipes melts the snow on the roads.

In Japan, just like in Finland, contractors and clients use information and communication technology to share information on road conditions and the operating status of snow removal machines, and some information is shared when installing equipment on roads. This information is provided to road users through road information display devices and snow removal station (road station) [2].

Additionally, in addition to these technologies, progress is being made in the development of snow removal machines that do not require operator operation, using self-position estimation technology such as GNSS and sensing technology such as LiDAR.

However, the focus in the development of these technologies is how to operate snow removal machines, and the impact of such improved and developed snow removal machine controls on operators was evaluated through hearings and questionnaires [3].

Therefore, in this study, we conducted hearing and recorded operator behaviour using a drive recorder, and analysed the filmed video using posture estimation software to see if a qualitative evaluation of operator behaviour could be made.

2 Material and Method

In order to identify current problems, we conducted a survey targeting snow removal work at Nagaoka University of Technology.

The reason for targeting the snow removal work at Nagaoka University of Technology was that the location and work conditions were suitable for the study.

The machine targeted for investigation was a rotary snowplow. A rotary snowplow is a snow removal machine that travels through accumulated snow, loosens the snow with an auger, sends the snow to a chute with a blower, and controls the direction in which the chute throws the snow.

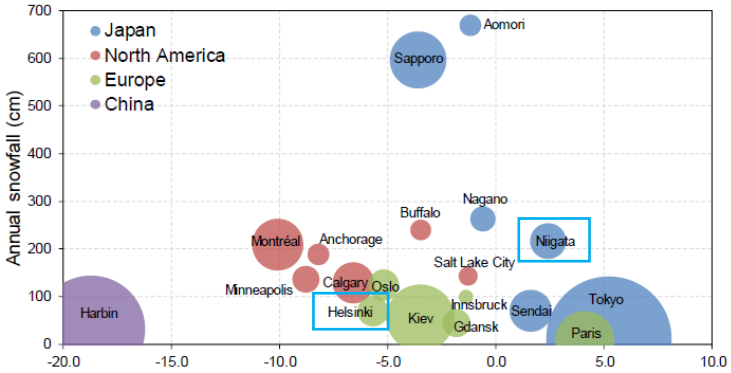
Exterior view of rotary snowplow

Auger and Blower

Figure 1 Exterior view of rotary snowplow, auger, and blower

Niigata Prefecture, where Nagaoka University of Technology is located, is an area where the average snowfall exceeds 200 cm, and a lot of snow can be expected during the survey period (Figure 2).

Additionally, since the snow removal work is on a university campus, it is expected that the work will be repeated under the same conditions [1].



Note: the size of the circle indicares the population of the city.

Figure 2 *Temperature and snowfall in major cities.*

The survey was conducted in two ways.
The first step is to hear from the operator about problems, requests, and key points of operation.
The interview was conducted with one manager and two operators of a company that contracts snow removal on the premises of Nagaoka University of Technology.
During the interviews, we walked along the routes where snow removal operations are actually carried out, and investigated incidents experienced by operators in the previous year and precautions to be taken during the work.
Second, a drive recorder was installed inside the rotary snowplow operator to record snow removal operations during snowfall.
The drive recorder used was "CL-8CM2" manufactured by Clarion. This drive recorder is a device that can simultaneously record images from up to 8 cameras, but this time we will introduce 4 images of the operator taken from the front of the vehicle, the left front of the vehicle, the right front of the vehicle, and the right side. I shot one video. Figure 3 shows the video actually shot.

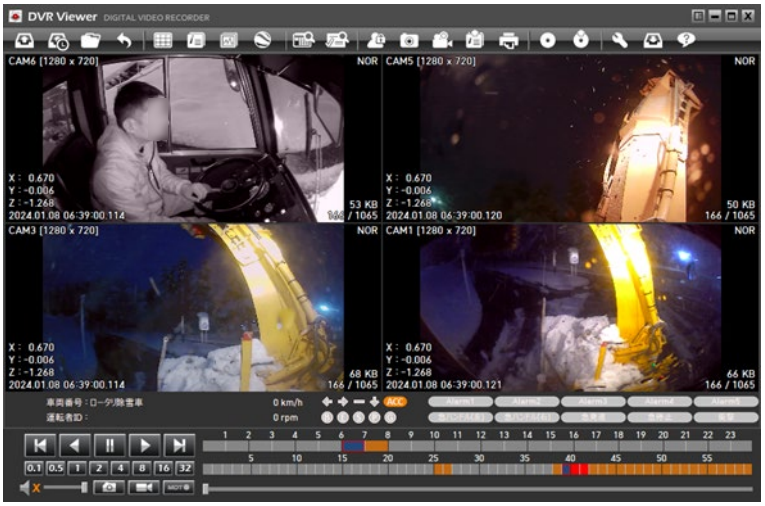


Figure 3 *Example of video recorded by a drive recorder.*

The work data targeted for analysis this time was recorded data from 6:50 to 7:20 on January 8th.
Analysis was performed using OpenPose (ver1.7.0. windows). OpenPose is an open source pose estimation software [4]. An example of pose estimation using OpenPose is shown below. In addition, sitting in a chair generally puts more strain on the lower back than standing, and it is known that leaning forward places a particularly heavy burden on the lower back when sitting in a chair. [5] Therefore, this time we decided to analyze the movement of the head. The reason for choosing the head and the point of extraction was that the displacement was considered to be the most pronounced.

3 Results

This hearing result said rotary snow removal machine operator worry about damage to road ancillary equipment and to occur snow jam of shooter. If snow jam of shooter occurs, the rotary snow removal machine operator must get out of the cockpit and use a shovel and his hands to remove the snow jam from the shooter. It was commented

when that ride on and off and removal of snow jam was burden on snow removal worker. The snow removal crew commented that getting in and out of those snow removal machine and removing snow jams was burdensome. It is also speculated that these phenomena are caused by the aging of rotary snowplows and the fact that snow becomes wet due to snow removal pipes, making it easier for snow to adhere to the surface of the shooter (Figure 4).

Figure 4 *Surface of the shooter.*

The result of the rotary snow plow operator motion was record by the drive recorder shows 4 sections operator's motions of snow removal work.

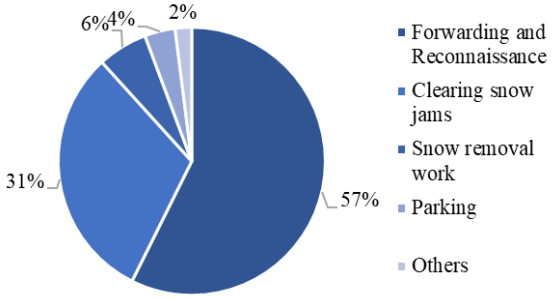


Figure 5 *Breakdown of each task in snow removal work.*

The first section is Moving and Previewing. While moving from one snow removal area to the next, the operator looks at snowfall conditions and determines the need for snow removal operations. In this survey Moving and Previewing section accounted for 57% of snow removal work, making it the most time-consuming part of the snow removal process.

The second section is Remove snow jam in the shooter of the rotary snowplow. This section is accounted for 31% of snow removal work in this survey. The shooter is a cylindrical structure that controls the direction in which snow is thrown. In addition, actions that supported the hearing comments included getting out of the driver's seat of the rotary snowplow to remove snow, as well as tapping the ground with the auger case to remove snow jams while in the driver's seat.

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The fourth section is parking. This section is parking the rotary snowplow to carport. This task accounted for 4% of the total worktime.

Figure 4 shows the changes in the coordinates of the head output by OpenPose. As a common point among the two graphs, it can be seen that the respective coordinates and reliability are 0 near 5,000 frames and 15,000 frames. This indicates that the subject is outside the field of view and pose estimation is not performed. At this time, the operator was observed getting out of the cab and clearing snow stuck in the shooter.

Also, before and after the frames (mark as read frames in the graphs) where pose estimation is not performed, the operator's head appears to be around 800px to 1000px on the x-axis and 400px to 700px on the y-axis.

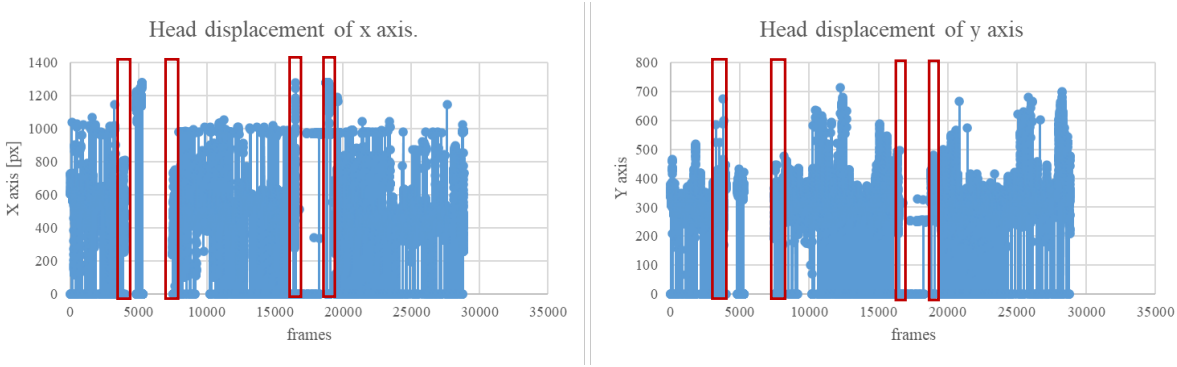

Figure 6 *Head displacement per frame.*

The data with low reliability were omitted from the data in Figure 6, and a diagram with the vertical axis as the Y-coordinate and the horizontal axis as the X-coordinate is shown in Figure 7. The omitted data were assumed to have a posture estimation reliability of 0.8 or less. At this time, if the range of 800 to 1000 px on the x-axis and 400 to 700 px on the y-axis shown in the red frame in Figure 4 is shown in the red frame in Figure 5, it is assumed that the coordinates of the head are in a posture stretching forward. You can see that there are.

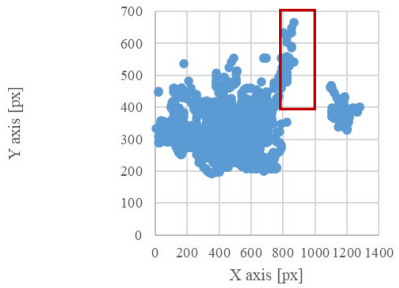

Figure 7 *Operator head quake excluding unreliable data.*

The number of occurrences of each coordinate is shown in Figure 6. From Figure 6, it can be said that the forward leaning posture suggested by Figure 5 is a non-stationary posture (mark as red frame of Figure 8).

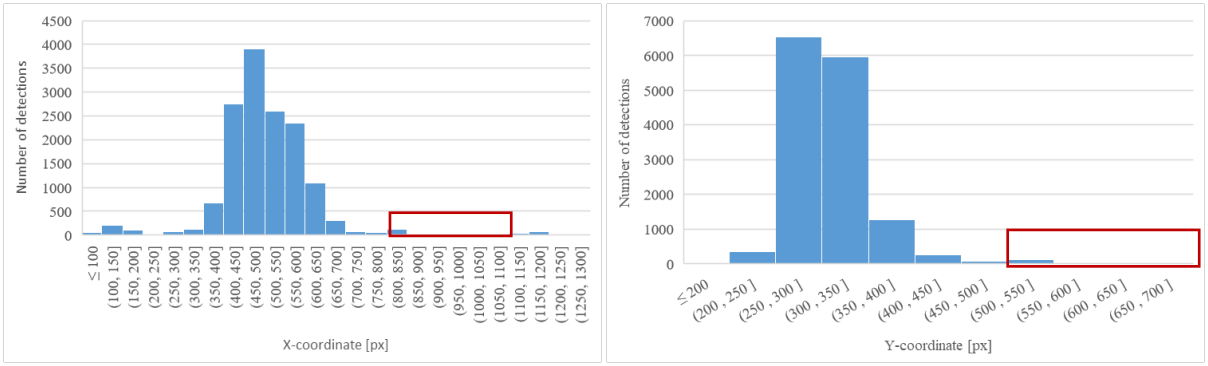

Figure 8 *Number of detections X-coordinate vs Y-coordinate.*

4 Discussion

The results show that the video footage taken by the drive recorder provides corroborative data for the results obtained from the interviews.

The results of the posture estimation revealed that operators lean forward when the shooter is clogged with snow in order to see what is going on.

These results suggest that operators may feel fatigue due to their posture collapsing in addition to the work of getting out of the operator's cab and removing snow jams from the shooter, and it is possible to evaluate the behaviour of snow removal machine operators by estimating their posture. The results were promising.

However, the time covered by the analysis in this study was short and it cannot be said that these results represent the general state of affairs in snow removal operations at Nagaoka University of Technology.
As a new issue based on the results, it is necessary to continue research in the same environment on the influence of factors such as the environment surrounding the rotary snowplow and the layout of the control levers and other controls on the behaviour of the operator.It is also considered possible to use posture estimation as one of the evaluation indicators for control levers and other controls in the cab of a rotary snowplow.

5 Conclusion

In Japan, snow removal machinery has been actively improved using information and communication technology in response to population decline, but methods for evaluating the impact of these improvements on operators have not been studied.
Therefore, this study examined the applicability of this method by conducting interviews and using posture estimation software to survey the behaviour of operators.
In this study, interviews with operators and analysis of operator behaviour using posture estimation software were carried out for snow removal operations on the premises of Nagaoka University of Technology.
Posture estimation and drive recorder footage confirmed that the amount of time spent by rotary snowplow operators removing snow jam in the shooter of rotary snowplow is disproportionately large compared to the time spent clearing snow, and that operators lean forward when snow is stuck in the shooter in order to see what is happening.
However, as the time covered by the analysis in this study was short, future analyses of similar tasks will be carried out to examine their applicability and more suitable approaches.

6 Acknowledgements

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