Title	デジタルツインを用いた除雪車運行計画による除雪作業支援システムに関する研究
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Research on snow removal operation support system by snowplow vehicle operation planning using digital twin

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Many municipalities and government agencies are currently promoting smarter technology through the introduction of technology and the utilization of data, and the digital twin is attracting attention as a foundation for this. Especially in the field of disaster prevention, a common technology platform is available that collects real-time data from IoT sensors, accurately reproduces the situation, and performs highly accurate simulations. In this paper, we propose a system that utilizes the digital twin to realize optimal snowplow vehicle operation planning as a snow disaster prevention measure.

Conventionally, snow removal decisions are made by supervisors after evening by checking weather forecasts, patrolling, and using observation point data, and work is performed during the night and morning. However, when sudden weather changes occur during the night, snow damage issues exist, such as large-scale vehicle stoppages and the resulting enormous damage. It is a heavy burden for the supervisor to predict the snow removal work environment with high accuracy over a long period of time and to make decisions on his or her own. To address this issue, a snow removal support system is required that automatically collects a wide range of information and can respond to changes in the environment after the decision to mobilize.

In constructing a snow removal digital twin, sensing data such as thermometers and anemometers will be collected. To reproduce snow accumulation conditions, reference will be made to demonstration experiments conducted by PLATEAU, a project led by the Ministry of Land, Infrastructure, Transport and Tourism. A simulation of the spatial distribution of snow accumulation due to wind and melting snow (OpenFOAM solver) will be performed to reproduce snow accumulation conditions on a digital twin. Areas where the snow accumulation reaches the snow removal dispatch criteria defined for each region are extracted as snow removal points, and the shortest route for all snow removal vehicles to pass through the snow removal points in the relevant area is calculated. Using the simulation results, a visualization is presented to the supervisor, which allows the supervisor to see images of snowfall conditions, changes in snow accumulation, snow removal vehicle travel conditions, and proposed future routes. Based on the proposed optimal routes, which are updated at regular intervals using real-time data, the supervisor can immediately give work orders according to the snowfall and snow removal work conditions. The system configuration provides feedback to the virtual space when conditions change.

The proposed system reduces the supervisor's burden of collecting and analyzing information. Management on the digital twin will facilitate coordination with operators and enable real-time proposals for each region. These effects are expected to improve the efficiency and accuracy of snow removal operations. Furthermore, supervisors will be able to take into account multiple objectives when making decisions on snow removal operations and snow removal routes, such as securing routes for emergency vehicles, prioritizing routes based on frequency of use, and considering areas with many people in need of assistance, in addition to efficient completion of snow removal operations.

A digital twin that responds to changes in real-time data, such as the one addressed in this paper, can be used as a common framework not only in the field of disaster management, but also in various other areas, such as traffic management and understanding the dynamics during urban events. Through such utilization, the effect of introducing the digital twin in public administration is expected to be very significant.