AppSG 6th meeting as a part of WG-B, ICG-16 in Abu Dhabi

“Smart Mobility & Transportation”

Autonomous Snow Removal System Utilizing Michibiki CLAS

Contribution to C2 (Affordable Energy),C3 (Sustainable Cities & communities) & C4 (Climate action)
As a countermeasure to mitigate Extreme Weather due to G-warming,

The contents herein is English translation of information kindly provided by NEXCO East Corp, Japan. On behalf of AppSG Japanese members, I would like to express special thanks to their cooperation to AppSG activity.

Oct 12, 2022

Yasushi Sakurai on behalf of Japanese Members

Social Problems to be Resolved

Snow removal vehicles require highly experienced skill to the drivers and operators due to extremely poor visibility of outside and various controls to avoid damage to surrounding structures. For example, snow blower (rotary type) must run on road shoulders avoiding collision with guardrails and snowplow height must be adjusted no to hit bumps on the road covered by snow. In order to augment drivers' and operators' skill, voice guidance system which informs locations of such potentially dangerous points has been a provision based on vehicles GPS point positioning. However, the system requires two persons per vehicle. Snow blower needs one driver plus one operator who adjusts augers (rotational peddles) height and snow shooting direction, Snowplow needs one driver plus one operator who adjust plow height. In addition to the manpower and skill problems, aging of experienced drivers/operators and low birth rate are the social problems which must be resolved very quickly. Under these circumstances, NEXCO EAST Corporate Japan has been developing autonomous system of snow removal vehicles utilizing Michibiki's cm-level augmentation system, CLAS, since 2019, and know-how transformation from the experienced not to the inexperienced but to its control box is ongoing. The system will be in full operation by the end of March 2023. We must note that center line is always invisible for this application and thus it is quite different from autonomous cars.

Snow blower operating to fit shapes of highway service area

Snowplows controlling plow height to avoid collision with road joints

Product's Overall Information

1. Contribution areas to SDGS and G-warming effect mitigate: C-2,C-3, C-4
2. Application area: Smart Mobility & Transportation
3. Social problems to be resolved : Ageing of the experienced with operation know how & low birth rate problem
4. Product/Service name: ASNOS (Advanced/Autonomous Snow and ice control Operation System)
5. Manufacturer/Provider/Developer: NEXCO EAST Corporate, Japan, https://www.e-nexco.co.jp, Address: Shin-Kasumigaseki Building, 3-3-2 Kasumigaseki, Chiyoda-ku, Tokyo, 100-8979, Tel:+81-3-3506-0111, E mail: k.usui.aa@e-nexco.co.jp
6. Date of Product Release/Service in: Full operation by the end of 2023
7. Price range: NA because of inhouse use
8. Price range: NA because of inhouse use
9. System description diagram, specifications: Described in following pages
10. Lessons learned and guidance to GNSS users: Described in following pages
11. References

https://qzss.go.jp/usage/userreport/nexco_210208.html
https://kurukura.jp/next-mobility/20210106-80.html#google_vignette
https://www.nikkei.com/article/DGXZQOUC0675T0W2A500C2000000/?unlock=1
https://travel.watch.impress.co.jp/docs/news/1367749.html

Product Specification Common to Snow Blower and Snowplow

Inside of Snow Blower driver's car room

2 GNSS antennas mounted on roof of Snow Blower driver's car

Major Specifications	
Used GNSS	Range signals from Galileo, GPS & Michibiki, CLAS augmentation data from Michibiki
Mount position of GNSS antenna	Two antennas on driver's car roof to measure both car position and travel direction
Other sensors co-used	IMU to measure inclinations of vehicle and feedback to positioning result with no camera aid
Other augmentation data	3D digital map prepared beforehand along roads to be serviced
Vehicle's positioning accuracy including control errors	20cm horizontal (P-V)
Number of driver/operator	Only one per one snow removal vehicle
Operation concept	Autonomous operation (driving & plow height control) except for emergency cases

System Configuration of Autonomous Snow Blower

Features

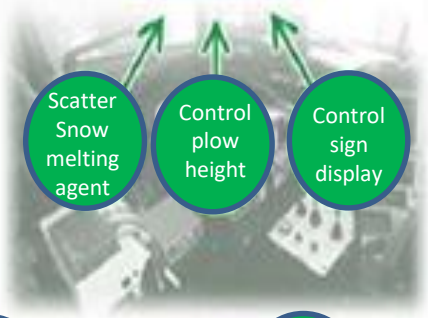
- Fully autonomous drive & operation including Augers' height and snow shooter's snow ejection direction operation except for emergency.
- No camera aid is used.
- Inclination of vehicle due to road shape and snow depth un-uniformity is cancellable by IMU data to minimize positioning error of GNSS antennas.
- Use 3D data of bumps on roads and guardrails recorded in 3D dynamic map in combination with GNSS positioning data.

Snow Blower system enabling autonomous driving and control of augers' (rotating paddles) height and snow shooter's direction per surrounding conditions using precise 3D dynamic map and CLAS receiver

System Configuration of Autonomous Snowplow

Centralized operation

Control panel



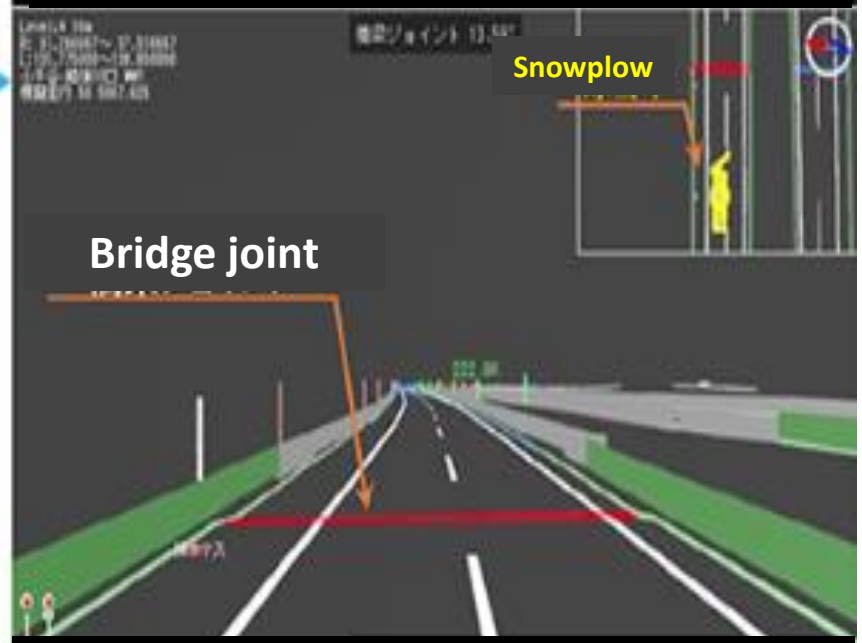
Automation developed

Automation Under final development

Automation developed

Voice guidance plus autonomous drive & operation

Main display image of control panel



3D dynamic display showing road and surroundings status toward travel direction

(Picture above is made by Prof. Yuzo Suga Lab. of Hiroshima Institute of Technology)

Features

- Fully autonomous drive & operation including control of plow's height, snow melting agent scatter and work sign display except for emergency.
- No camera aid is used.
- Inclination of vehicle due to road shape and snow depth un-uniformity is cancellable by IMU data to minimize positioning error of GNSS antenna
- Use 3D data of bumps on roads and guardrails recorded in 3D dynamic map in combination with GNSS positioning data. .

Snowplow system enabling autonomous control of plow height per bumps like road joint, snow melting agent scatter and work sign display using precise 3D map and CLAS receiver

Lessons learned and guidance to GNSS users

1. At an initial development stage, only one QZSS satellite for experimental service was available and it was hard to allocate appropriate time window for our experiment using centimeter level augmentation data from the satellite. After 24 hours continuous service using 4 Michibiki satellites which started in November 2018, the development has been enjoying its convenience.
2. Snow removal vehicles are mainly used in high attitude area in Japan, such as Hokkaido, satellite-based augmentation data from geostationary orbit becomes naturally from low elevation angle and is hard to use on roads in valley and mountain areas. Michibiki's CLAS is always available from at least one satellite at quasi zenith position (60 to 88 deg), and therefore is very powerful aid for our system. In addition, CLAS augments ranging signals from constellations of GPS, Galileo and Michibiki, total 17 satellites as minimum, and provides stable positioning accuracy even in blizzard conditions. When snow removal is required, roads are fully covered by heavy snow and center line is invisible. The camera system which normally plays the most important role for autonomous car by observing center lines is therefore not applicable and reliable.
3. The development is basically an integration of existing technology and components available on the market, but we have been continuously improving the system integrating opinions and inquiries by the drivers, operators, road maintainers, etc. from diversified viewpoints aggressively.
4. CLAS which is Japan-limited regional service, but any other augmentation data directly transmitted from satellites, from high elevation angle, if possible, can replace to develop similar systems.