topics

Driverless Antarctic Tractor System

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OVERVIEW: A driverless Antarctic tractor system was developed in response to a request from the National Institute of Polar Research (an Inter-University Research Institute Corporation Research Organization of Information and Systems) for a vehicle that could be used to transport supplies from the coast to the interior of the Antarctic continent. In addition to conventional operation by a driver, the system is also capable of automatically trailing another vehicle using a combination of autonomous driving and positioning information from a variety of sensors, including gyroscopes and GPS positioning data transmitted from the driver-operated vehicle. The aim for the future is to improve the efficiency of goods transportation in the Antarctica through the adoption of fully automatic systems, such as operating a number of tractors automatically in a convoy, or converting driver-operated vehicles to driverless operation.

TRANSPORTATION EFFICIENCY ENHANCEMENT

ON the Antarctica, sleds pulled by driver-operated snowcats are used to transport supplies from coastal to inland bases. The trip to the inland base takes about three weeks of driving 10 hours a day, and forces staff to put up with the vibration and other discomforts of travelling across snow and ice. The driverless Antarctic tractor system was developed to make life easier for staff and to improve transportation efficiency by giving the tractor the ability to follow another vehicle automatically.

SYSTEM OVERVIEW

The driverless Antarctic tractor system consists of a driver-operated snowcat, a driverless tractor, and the electronic equipment mounted in each of these vehicles (see Fig. 1).

The driverless tractor uses its own global positioning system (GPS) position and orientation information together with the GPS position information on the driver-operated snowcat as the basis for automatic trailing. Images from the monitor cameras installed on the front and rear of the tractor can be displayed on a panel personal computer (PC) located in the driver-operated vehicle. Also, to prevent collisions, image recognition is used on the images from the tractor's front-end camera to detect and calculate the distance to a target mounted on the rear of the sled pulled by the driver-operated snowcat.

The panel PC on the driver-operated snowcat is also used to display information and issue commands to the tractor, such as initiating or cancelling automatic trailing. The information includes the status of the driverless tractor and waypoints along the route being traveled by the vehicles (target coordinates set at roughly 2-km intervals).

TRAILING METHOD

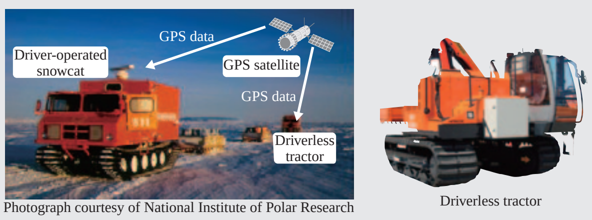
The automatic trailing function of the driverless Antarctic tractor system calculates the direction (θ) of the target point based on GPS position information from each vehicle, and calculates the angle to turn (ω) from the distance (d) and speed (v) of the driverless tractor at 1-s intervals (see Fig. 2).

TRAILING PERFORMANCE

The position provided by GPS can vary from the actual position due to a variety of factors. To cope with this, work was done on the two objectives described below to improve the trailing performance of the system.

(1) Reduce positioning error.

When trailing another vehicle, the most important variable is the relative position of the driver-operated



Photograph courtesy of National Institute of Polar Research

GPS: global positioning system

Fig. 1—Driverless Tractor System.

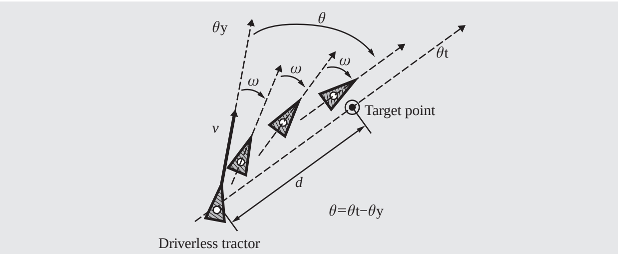


Fig. 2—Vehicle Turn Calculation.

and driverless vehicles. To obtain this, an electronic reference point (which would normally be located on the ground) is positioned on the driver-operated snowcat, and realtime kinematic (RTK) GPS*1 is used to determine its distance and direction. This reduces the relative positioning error to about 20 cm or less.

(2) Minimize impact of positioning errors.

Rather than always pointing directly toward the driver-operated snowcat, the driverless tractor sets target points along the trajectory of the driver-operated snowcat. This means that any variation in the GPS positions has a greater effect the shorter the distance (d) to the next target point, causing the trailing error to increase (see Fig. 3). A human driver typically looks a certain fixed distance ahead of the vehicle. In the same way, the driverless tractor progressively switches to new target points as it moves along, always using a measurement point located more than a certain minimum distance ahead as its next target point.

By using this forward-directed model, which sets the turning angle in proportion to the horizontal deviation from the target point, the trailing operation can be performed in a way that minimizes the influence of measurement variation. Table 1 lists the results of simulation for different values of distance (d). Using target points located 20 m ahead reduces the trailing error compared to a target distance of 5 m.

ACTUAL PERFORMANCE

To approximate conditions in Antarctica, the system was tested on a snowfield that was free of obstacles. The tests demonstrated that the driverless tractor could follow the driver-operated vehicle without significantly deviating from its path, including around sharp corners with a 20-m turning radius. Additional tests were conducted driving up a snow-covered slope to simulate driving over the sastrugas*2 found in Antarctica. This demonstrated that the driverless tractor could successfully follow the lead vehicle up and down slopes with an incline of approximately 20°.

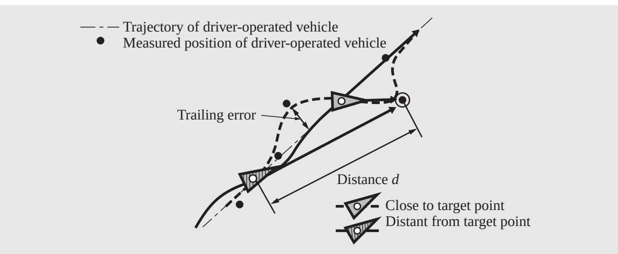


Fig. 3—Effect of Variation.

TABLE 1. Results of Simulation at Different Distances (d)

Distance d (m)	5	10	15	20
Trailing error (m)	10.1	9.7	2.5	1.7

In addition to proposing systems for making transportation even more efficient, including operating a number of tractors in convoy or converting driver-operated vehicles to driverless operation, Hitachi intends to contribute to a safe and secure future society by supplying control solutions for a wide variety of applications, including automatic control systems.

*1 A realtime method for measuring the position of a moving vehicle that works by transmitting information for correcting measurements to the vehicle from an electronic reference point (known location). To improve positioning accuracy, the distance between the electronic reference point and moving vehicle needs to be kept within about 10 km.

*2 Ridges formed on the surface of snow in Antarctic continent that can reach up to nearly 2 m in height.

REFERENCES

(1) K. Watanabe et al., “A Study of Lane Change Maneuver of Tracked Vehicles,” Transactions of the Society of Automotive Engineers of Japan (Apr. 1997) in Japanese.

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