A New Train Position Detection System Using GPS

Yasutaka MAKI
Assistant Senior Researcher, Running Gear, Vehicle Structure Technology Division

Railways in Japan have many sections in which there is a succession of sharp curves. In order to permit the trains to negotiate those curves at higher speed, a controlled tilting train was developed and put into operation. The controlled tilting train has contributed much to improvements in passenger services, including shorter traveling time. Although proactive R&D on the hardware of tilting trains has been carried out, the software (the method used to detect the current positions of trains) has remained unchanged. Working with these conditions, we have come up with a new train position detection system using GPS-a system that is not dependent on such ground markers as the ATS (automatic train stop) ground coil, and which offers a positioning accuracy equal to or higher than the conventional system.

Accurately detecting the current position (calculating the longitude and latitude) of a train by GPS in a mountainous area, tunnel or urban area is so difficult that it is necessary to supplement the conventional detection method with another method. In this respect, we worked out a data reception reliability coefficient as an index of positioning accuracy based on satellite information (number and arrangement of the satellites involved) and decided to perform one of three different types of data processing according to the value of that coefficient (Fig. 1). Our system detects the current position of a running train by using in combination the advantages of these three methods: ① GPS data, ② track curvature and ③ wheel rotating pulse count by tachometer generator. The GPS, which offers absolute coordinates, cannot be used at places which are out of reach of radio waves. Besides, depending on signal reception conditions, the accuracy of positioning by GPS deteriorates markedly. The track curvature can be checked easily since it has good repeatability. Even so, it is necessary to give a point at which to start the checking. The wheel rotating pulse count by a tachometer generator offers a high positioning accuracy in short sections. But even in this case, it is necessary to give a point at which to start counting. The three different methods of position detection used by our system have characteristics that are complementary to one another. By utilizing the advantages of the three methods in combination according to the accuracy of positioning by GPS, it is possible to build a train position detection system that is accurate and stable. The system configuration is shown in Fig. 2.

Collation of the measured curvature with the curvature map is performed as follows. First, the current position is roughly determined from the GPS data or the wheel rotating pulse count by the tachometer generator, and that position is taken as a tentative current position (Fig. 3). Next, with the tentative current position as the initial value, data relating to the sections before and after that position are extracted from the curvature data (curvature map) that has been obtained during a preliminary run. Then, the curvature data for section a[m] immediately before the current position observed during the run is compared with the extracted portion of the curvature map. The true current position is obtained by shifting the tentative current position till the point at which the two data coincide with each other is found.

For the purpose of verifying the accuracy of position detection by our system, the results of position detection obtained during a train run through 15 fixed points on the ground were extracted (Fig. 4). As a result, it was confirmed that our system had a positioning accuracy equal to or higher than the conventional system, with the positioning error being within ±4 m.

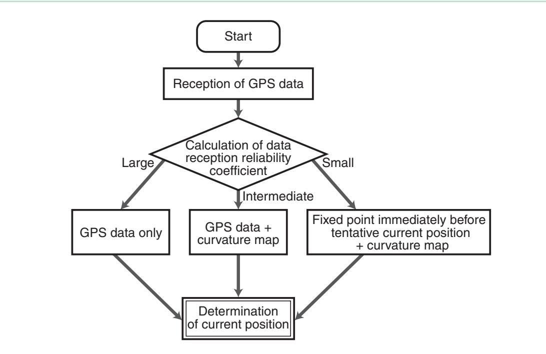

Figure 1. Flow of data processing for position detection

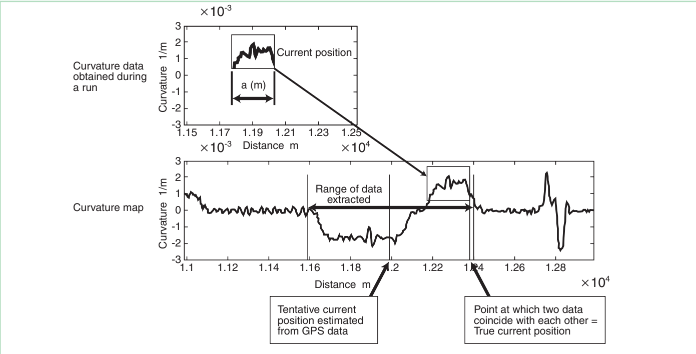

Figure 3. Collation with curvature map

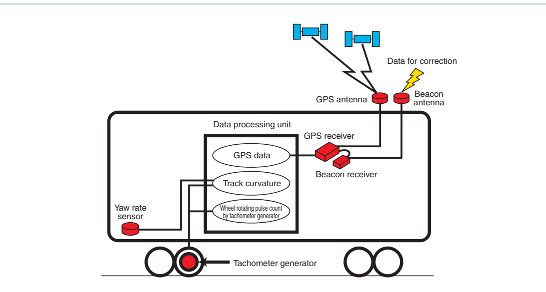

Figure 2. System configuration

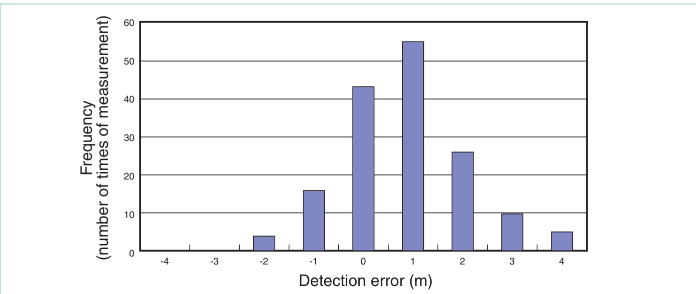

Figure 4. Detection error distribution