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Subway rail transit monitoring by built-in sensor platform of smartphone

Key words: Acceleration signals; Smart monitoring; Embedded sensors; Smartphones; Subway

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Introduction

1. Abandoned smartphones were used as a sensing platform for subway monitoring.

2. A mileage positioning method is proposed and verified for the GPS-free tunnel environment.

3. Field tests were conducted to verify the accuracy of smartphones in regard to ride comfort indexes.

4. A coordinate alignment method by the maximum likelihood principle can ensure convenient detection operation by smartphones.

Findings

1. Comparisons of vertical and lateral accelerations obtained from smartphones and high-precision sensors showed that smartphones can be used to detect the vibration response of the vehicle body and evaluate the ride comfort of the vehicle.

2. The field test results showed that the integrated distance deviation between stations can be controlled to within 5% after line curve information correction.

3. The proposed approach can estimate the location of the subway vehicle in an environment without the GPS signal and is advantageous in quickly locating abnormal track defects.

Method

Explore whether the performance of the built-in accelerometer of smartphones can meet the needs of practical applications.

Fig. 4 Field test setup

Method (Cont'd)

The direction of the smartphone coordinate system (x', y', z') and the direction of the vehicle body coordinate system (x, y, z) are not completely aligned; there exists an angle θ between the longitudinal axis and the traveling direction of the vehicle.

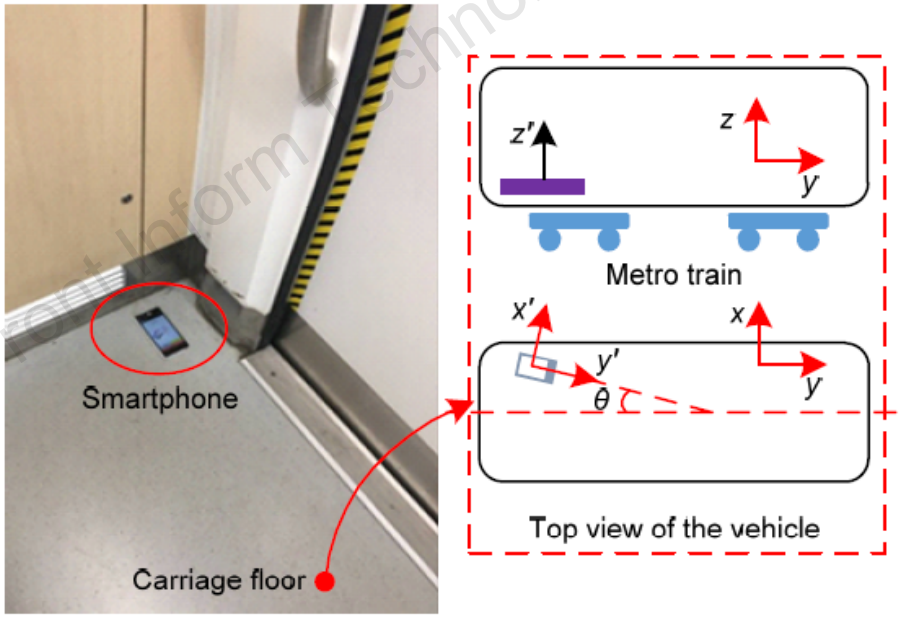


Fig. 7 Placement points of the smartphone during the field test

Method (Cont'd)

We propose a comprehensive method to find the location of a vehicle based on the smartphone accelerometer and gyroscope fusion method.

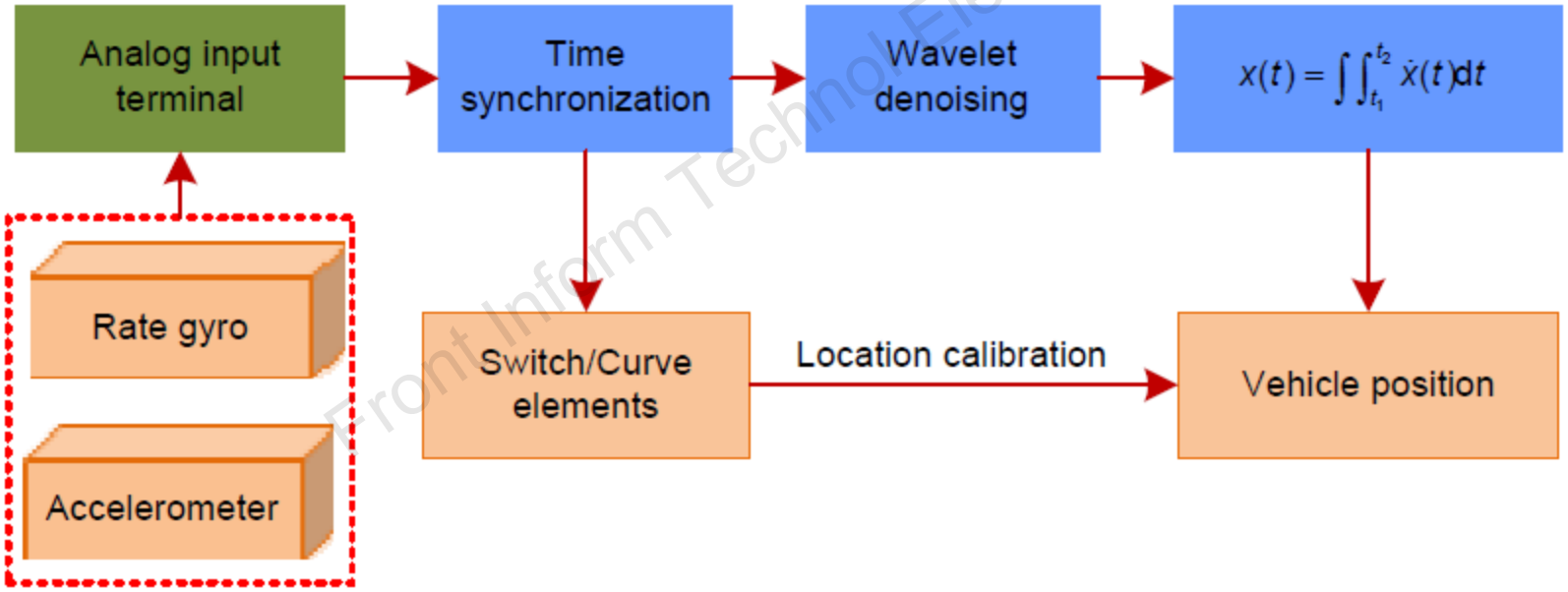


Fig. 5 Flowchart of vehicle location correction

Major results

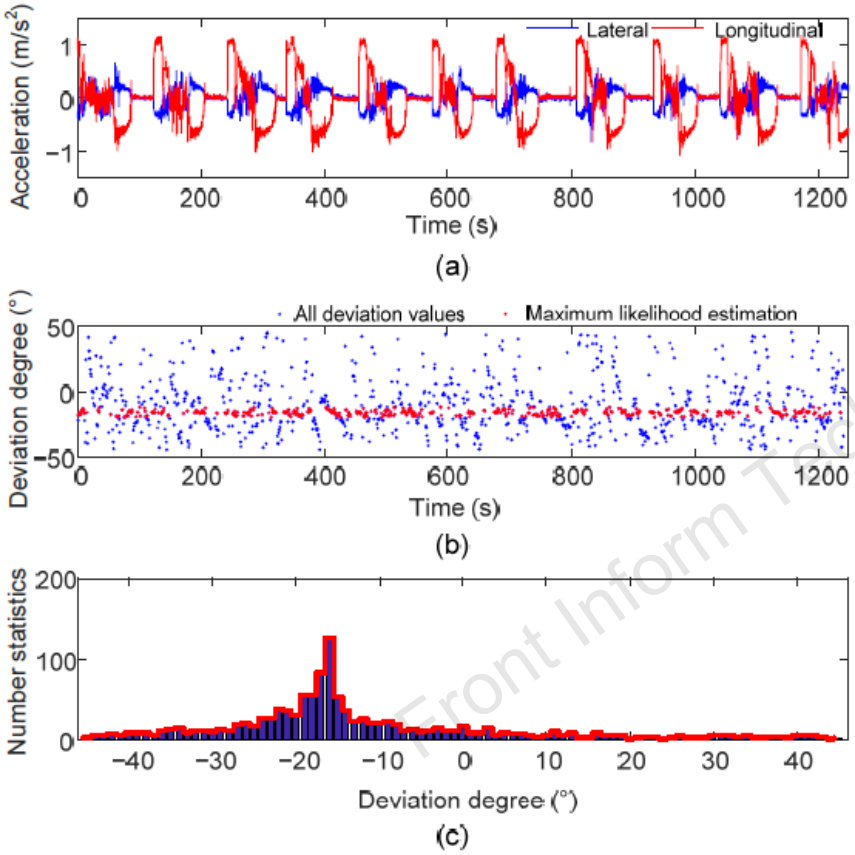


Fig. 9 Smartphone lateral and longitudinal accelerations after coordinate alignment (a), all deviation degree (b), and statistical distribution histogram of the deviation angle (c)

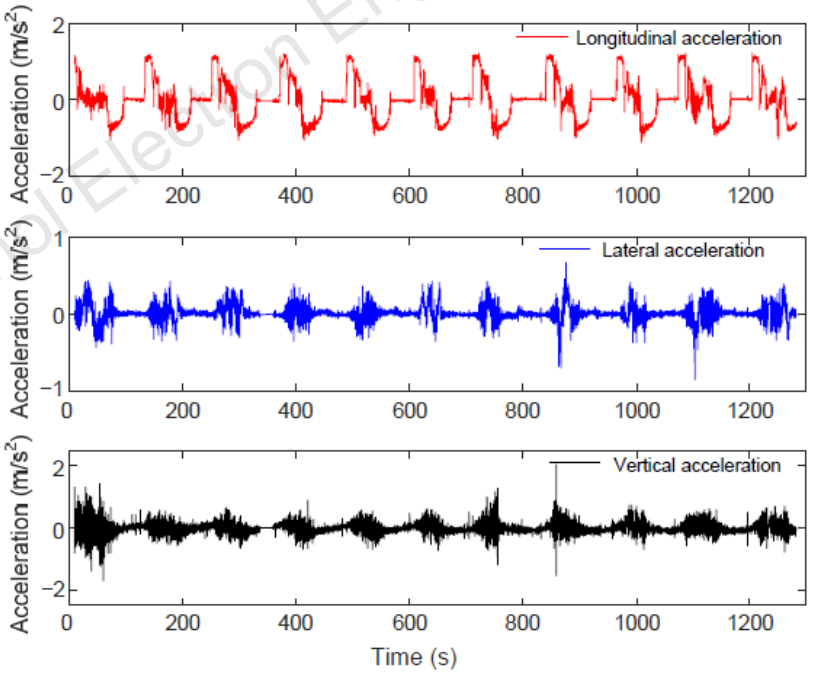


Fig. 10 Actual vibration accelerations of the vehicle body after coordinate alignment

Major results (Cont'd)

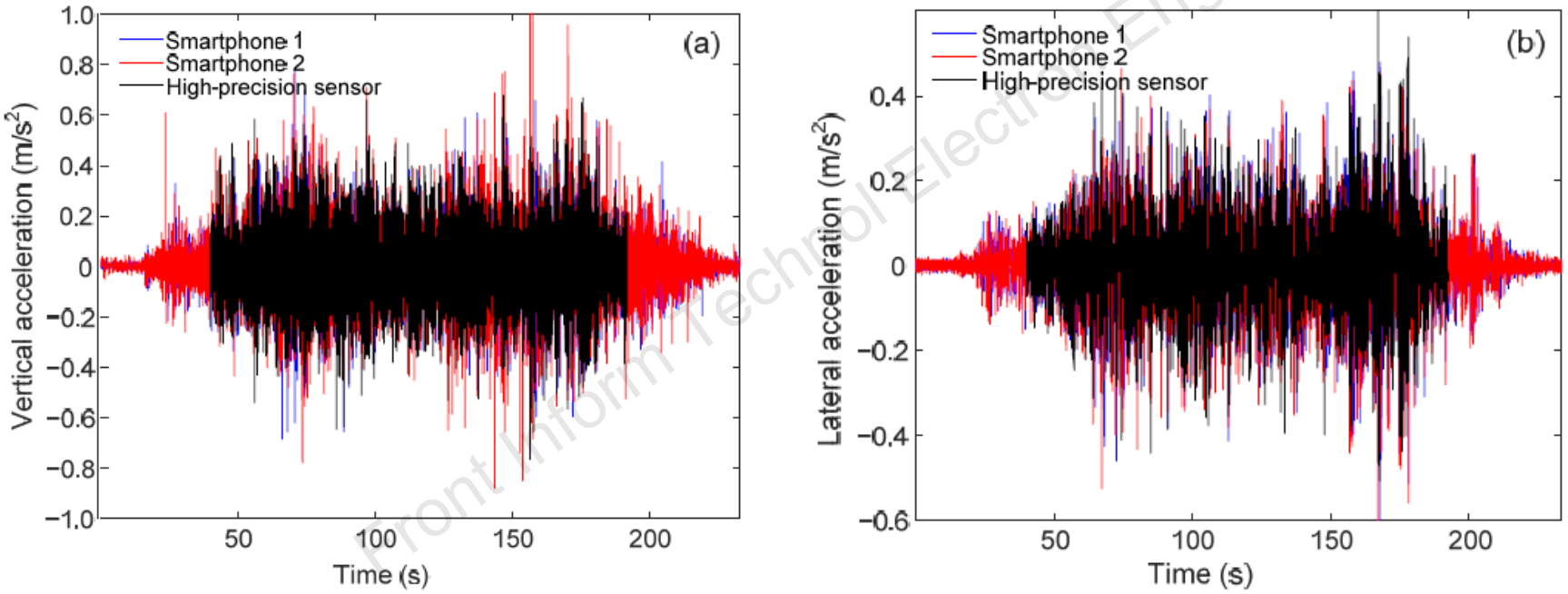


Fig. 11 Comparison of vertical (a) and lateral (b) accelerations obtained from smartphones and high-precision sensors

Major results (Cont'd)

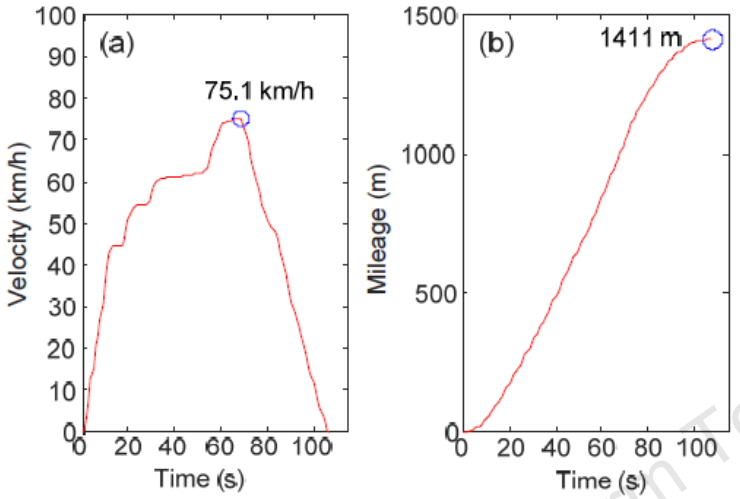


Fig. 13 Actual vehicle velocity (a) and mileage (b)

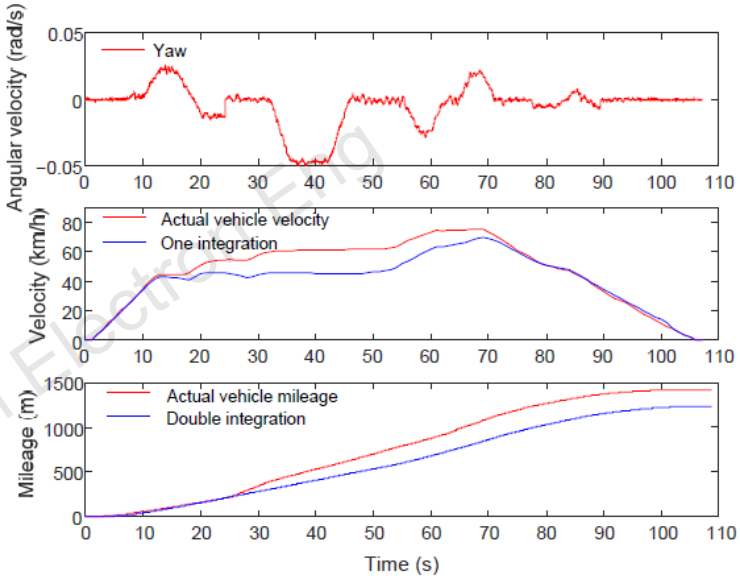


Fig. 16 Vehicle yaw angular velocity, speed, and location

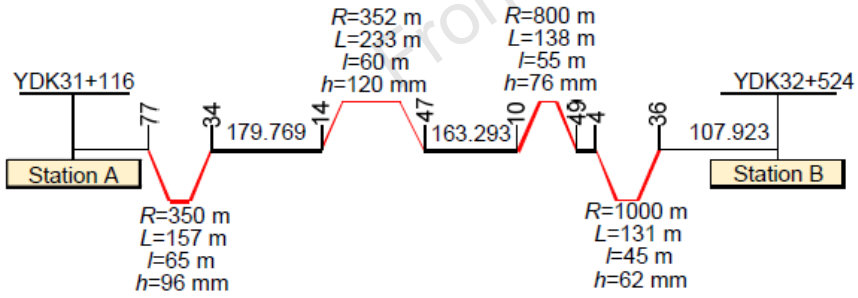


Fig. 14 Station A to station B: subway line curve information

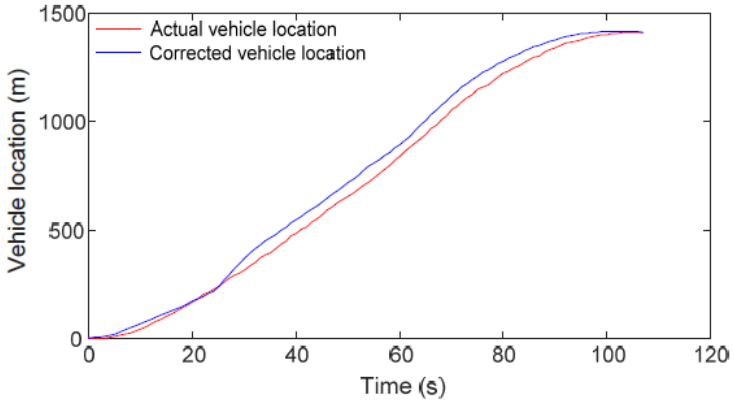


Fig. 17 Vehicle location after curve information correction

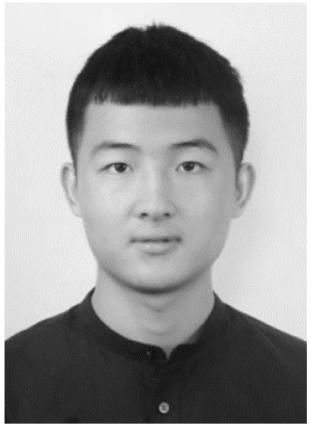
Conclusions

1. The built-in accelerometer of smartphones plays an important role in obtaining the acceleration information of the vehicle body.

2. The proposed coordinate alignment method is capable of achieving convenient detection operation by smartphones.

3. The field test results showed that the integrated distance deviation between stations can be controlled to within 5% after line curve information correction.

4. The proposed approach can estimate the location of the subway vehicle in an environment without the GPS signal and is advantageous in quickly locating abnormal track defects.



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