Advances in Positioning

“SubwayPS: Towards Enabling Smartphone Positioning in Underground Public Transportation Systems”

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Note:
Richmond-Millbrae trains terminate at Daly City in the evening and on weekends, and Pittsburg/Bay Point-SFO trains continue to Millbrae in this event.
SubwayPS: Towards Smartphone Positioning in Underground Public Transportation Systems

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ABSTRACT
Thanks to rapid advances in technologies like GPS and Wi-Fi positioning, smartphone users are able to determine their location almost everywhere they go. This is not true, however, of people who are traveling in underground public transportation networks, one of the few types of high-traffic areas where smartphones do not have access to accurate position information. In this paper, we introduce the problem of underground transport positioning on smartphones and present SubwayPS, an accelerometer-based positioning technique that allows smartphones to determine their location substantially better than baseline approaches, even deep beneath city streets. We highlight several immediate applications of positioning in subway networks in domains ranging from mobile advertising to mobile maps and present MetroNavigator, a proof-of-concept smartphone and smartwatch app that notifies users of upcoming points of interest and alerts them when it is time to get ready to exit the train.

Categories and Subject Descriptors
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

Keywords
mobile navigation, positioning, mobile devices, accelerometer, public transportation, TPS

Red dots are underground stations. One could easily miss their stop if they relied solely on current positioning.
Key Types of Signal-based Positioning

in your smartphone and in general

1. Satellite-based Positioning
2. Wifi Positioning
3. Cellular Positioning

Signal-based Positioning
Indoors

GNSS  Wifi  Cell

Slides for Spatial Computing MOOC (by Brent Hecht)
Urban Canyon

GNSS  Wifi  Cell
Rural areas

GNSS

Wifi

Cell
Subways

Slides for Spatial Computing MOOC
(by Brent Hecht)
Location-based advertising using subway positioning:

Exit at the next stop for a free slice of pizza!
Subways

GNSS  Wifi  Cell

SubwayPS

Slides for Spatial Computing Mooc
(by Brent Hecht)
Sensors → Internet → Smartphone

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Slides for Spatial Computing MOOC
(by Brent Hecht)
Accelerometer readings from the Central Line in London
Accelerometer readings from the Central Line in London
Stop Detection

Official Timetable

Smartphone Position

along a subway line

(by Brent Hecht)
Stop Detection:

85% accurate across four subway systems
Whole Trip Accuracy:

78% of trips tracked perfectly

42% baseline of using timetable only
MetroNavigator

a) MetroNavigator

b) Unscheduled stop
   We've stopped but not at a station.
   Expect a delay.

c) Unexpected event
   Oh, this is a bumpy ride and not so
   smooth as normal. Maybe worth to
   share?

d) Point of interest
   you're now crossing under
   Cologne Cathedral
   (Kölner Dom)
As my GPS does not work here, this is like a GPS for undergrounds trains – I want to have it integrated in Google Maps” (Participant 3)

“It is just cool to see the train moving and stopping on the map – I feel safer when I can see that we have stopped close to the next station when we’re stopped in the middle of a tunnel” (Participant 11)
Oops, it seems that the system missed a stop – that is not good. I would also be happy to help the system to detect the stops, if the system could help me to get out at the right station. That would be totally fine with me.” (Participant 3)
Future Work

Correcting for drift errors
Advances in Positioning

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Attributions

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