Positioning with Punctured GPS

by

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GPS in a cell-phone ...

... must not cost much, so

- hardware resources are shared
 - common antenna, receiver chain blocks, I/O ports
 - shared processor

... must not use much power, so

- the GPS receiver is turned off most of the time
- ... cannot operate during transmission, so
- the GPS receiver may have to wait
- ... must work indoors, so
- the GPS signals may be fading deeply



GPS in a cell-phone ...

All of this means that there are gaps in the GPS data stream. Can we extrapolate PR & PRR over the gaps to maintain track?





GPS in a cell phone

Possible operating modes:

- Outside, continuous
- Inside, continuous
- Outside, interrupted
- Inside, interrupted

Error components:

- thermal noise
- clock jitter
- GPS time estimation error
- error in the receiver's current position
- signal propagation effects such as multi-path



Range prediction ...



Pseudorange can be extrapolated across a gap using a low-order model



Indoor multi-path ...

Much has been said about multi-path. We made our own measurements inside my office at the Cavendish Laboratory, Cambridge, and in the spacious entrance hall of the German Space Operations Centre near Munich.



We used a master-slave receiver













Signal-to-noise ratio ...

Variation of C/N₀ (SV9 2008-04-15)





Repeatability of the measurements ...

SV26 on two successive days: Rx2



SV26 on two successive days: Rx3





Temporal correlation ...





Extrapolation (static channel)...

RMS prediction error



Extrapolation time interval / s

Extrapolation of a linear fit over 5 s Average of data for two SVs, each taken over 2 days



Range Offset: SV 26



- Indoor antenna separation: 0.05 m
 - Average range offset: 4.70 m

Correlation coefficient: -0.35





The spatial correlation has all but disappeared by $\lambda/4$





There is significant spatial correlation at 16 λ







Suggested power spectral densities ...





In conclusion ...

In the indoor environments tested here:

- puncturing the data stream would not have limited GPS positioning performance:
 - multi-path errors were well within ± one tenth of a chip
 - the re-acquisition transient was acceptable
 - the effect on the PRR was highly sensitive to the speed
 - averaging over 0.1 s would yield a good estimate of PRR

Measuring in many environments typical of mobilephone use is needed to test these conclusions

