Joint Twin-Cell Detection for Spread Spectrum Code Acquisition in the Presence of Fractional Doppler Frequency Offset

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It is essential to synchronize a locally generated pseudo noise (PN) code with the received one in DS/SS systems.

- **Code acquisition**
  - Aligns the phase of the locally generated PN code and the received one within a small range.

- **Code tracking**
  - Performs finer adjustment to bring the difference of the two phases close to zero and maintains the code phase synchronization.
Motivation

Fractional Doppler Frequency Offset (FDO) Effect

$D_{\hat{f}_D} L T_C$

$\Delta: \text{Cell Spacing}$

$\delta \in (0, \Delta): \text{FDO}$
Motivation (Cont’d)

- Conventional detection schemes
  - Do not consider the FDFO

- In practice
  - The FDFO is inevitable
  - The FDFO might cause serious performance degradation

- In this presentation
  - A novel detection scheme robust to the FDFO is proposed
Joint Twin-Cell Detection Scheme

Noncoherent Matched Filter Correlator

Joint Twin-Cell Detector

Decision

$t = nT$

$x_n$

$x_{n-1}$

tracking

acquisition

no acquisition
Performance Analysis

- Correlation output
  \[ x_{n-1} = P \text{sinc}^2(1 - \delta), \quad x_n = P \text{sinc}^2(\delta) \]

- Decision variable in joint twin-cell detector
  \[ y_n = x_n + x_{n-1} \]

- Probability density function

\[
\begin{align*}
  f_{x_n}^1(x) &= e^{-(x+s_n)} I_o(2\sqrt{xS_n}) \\
  f_{y_n}^1(y) &= \sqrt{\frac{y}{S_n + S_{n-1}}} e^{-(y+s_n+s_{n-1})} I_o(2\sqrt{y(S_n + S_{n-1})}) \\
  s_n &= PT \sin c^2((f_D - \hat{f}_D^n)T) / N_0, \quad I_\alpha(u) = \sum_{k=0}^{\infty} \frac{(u/2)^{\alpha+2k}}{k!\Gamma(\alpha+k+1)}
\end{align*}
\]
Simulation Results

- System parameters
  - PN code sequence of period $L=32767$ chips
  - Chip rate of 1MHz
  - Doppler frequency offset range of $\pm 10kHz$
  - $\Delta f = T^{-1}$ (i.e., 1KHz) and $(2T)^{-1}$ (i.e., 500Hz) with $T=1000T_c$
  - False alarm probability: $P_{FA} = 10^{-2}$
  - Monte Carlo integration with $10^7$ runs
Simulation Results (Cont’d)

- Detection probability of the conventional and proposed schemes for $\delta = 0$ and 0.5 when $\Delta f = T^{-1}$

![Graph showing detection probability vs. SNR/chip in dB for $\delta = 0$ (best) and $\delta = 0.5$ (worst) for both conventional and proposed schemes. The graph includes theoretical and simulation results.](image)
Simulation Results (Cont’d)

- Averaged detection probability of the conventional and proposed scheme.
Conclusion

- Using two consecutive correlator outputs
  - The joint twin-cell detection scheme has been proposed.

- Compared with the conventional scheme
  - The proposed scheme
    - is more robust to the FDFO
    - has better performance in general