Spread Spectrum Techniques for Simultaneous Multi-Source Seismic Acquisition

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OUTLINE

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Introduction: Simultaneous Sources

1. Multiple airguns (Beasley, 2007).
2. DSSS (Bouska, 2010).
3. HFVS (Krohn et al., 2010 - variphas.)
Pecholcs et al., 2010:
- 24 vibrators running simultaneously;
- > 40,000 vibe points in 24 hours.

Sallas et al., 2010, 2011:
- vibrator pilots = modified Gold codes;
- Gold codes are weakly correlated.
Pseudorandom Binary Sequences (PRBS)

- m-Sequences (maximal-length sequences);
- Gold codes (Gold, 1967);
- basis for spread-spectrum techniques widely used in science and engineering.
**m-Sequences and Gold codes:**

- **Periodic entities with -1 and +1 values.**
- **Autocorrelations are periodic triangular spikes (mimic white noise).**
- **Each entity is defined by** $m$, $L$, and $t_b$ :
  \[
  L = 2^m - 1.
  \]
- **The period in milliseconds is**
  \[
  T_m = L t_b.
  \]
$m = 11$
$L = 2047$
$t_b = 4\, ms$
$t_s = 1\, ms$
Controlled Source Acquisition

**Frequency Sweep**

**m-Sequence**
Spread Spectrum Acquisition and Simultaneous Multiple Sources
Quality of separated signals depend on how “orthogonal” the set of pilots are under (circular) correlation.

The less crosstalk in the cross-correlations of the pilots, the more “orthogonal” they are.
PRBS Degree= 11; Sequence Length= 2047

Normalized Amplitude

Time, msec.
Source function with a strong and a very weak event

no AGC

with AGC
Convolutions $R_i(t) = \int w(t-\tau) S_i(\tau) \, d\tau$, delayed by arrival times
Comparison of Gold-code and m-Sequences as Pilots For Vibrators Operating Simultaneously
PRBS Degree= 11; Sequence Length= 2047
Possible Applications
SIMULTANEOUS MULTIPLE SOURCES

Physical Modeling:
10 piezopin transmitters

Crosswell Scanning:
8 downhole vibrators
SIMULTANEOUS MULTIPLE SOURCES

Marine Surveys: SONAR sources

Land Surveys: Mechanical vibrators
Summary

Operating multiple vibrators simultaneously results in large gains in field survey efficiency.

- Shifted m-sequences or Gold codes can be used as pilot signals for simultaneous sourcing.

- Numerical simulations suggest m-sequences are the better choice because of much lower correlation noise and crosstalk.

- Extensive experimental testing (real surveys) needed to verify that the PRBS/correlation method adequately separates weak signals due to one source from strong signals due to another source.
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REFERENCES


