A BLOCK FACTOR ANALYSIS BASED RECEIVER FOR BLIND MULTI-USER ACCESS IN WIRELESS COMMUNICATIONS

We present a technique for the blind separation of DS-CDMA signals received on an antenna array, in the context of multi-path propagation with Inter Symbol Interference (ISI).

Our method relies on a new third-order tensor decomposition, which is a generalization of the parallel factor (PARAFAC) model.

**Communication System**

- **Blind Signal Separation: Why?** Estimation of the data relative to each user without prior knowledge of the learning sequence.
- Get higher communication rate.
- Ease error-correcting and error-dropping.
- Source localization.
- Case of learning sequence unavailable or partially received.

- **Parameters and propagation model:**
  - $K$: Nb of users, transmitting at the same time within the same bandwidth.
  - $J$: Spreading Factor of CDMA codes.
  - $L$: Nb of receiving Antennas.
  - $P$: Nb of reflected paths per user (Multipath Propagation).
  - $t$: Nb of receiving Antennas.

- **Over-Sampled Received Signal: Analytic Form**

\[
Y_{jk} = \sum_{r=1}^{K} \sum_{p=1}^{J} a_{r} (\theta_{mp}) \sum_{l=1}^{L} h_{p} (i + (l - 1) f) s_{j,l+1}
\]

- **Over-Sampled Received Signal: Algebraic Form**

\[
Y = A \times S \times R
\]

**Uniqueness of the Decomposition**

- If BFM unique (up to some trivial indeterminacies): separation of the different user signals and estimation of the transmitted sequences is possible.

**Summary of the ALS algorithm**

1. **Initialize** $S^{(n-1)}$, $H^{(n-1)}$, $n = 1$.
2. **ALS Steps:**
   - Find $A^{(0)}$ from $S^{(n-1)}$ and $H^{(n-1)}$.
   - Find $S^{(0)}$ from $A^{(0)}$ and $H^{(n-1)}$.
   - Find $H^{(0)}$ from $A^{(0)}$ and $S^{(0)}$.
3. **Repeat from 2 until** $c(n) < \epsilon$ (e.g. $\epsilon = 10^{-3}$),
   - where $c(n) = \left\| Y - Y^{(n-1)} H^{(n-1)} A^{(n-1)} \right\|_{F}^{2}$
   - Increase $n$ to $n + 1$

**Experimental Results**

- **Performance in presence of AWGN.** Noisy tensor of observation: $Y_{jk} = Y + N$.
- **Parameters:** $I = K = 6$, $J = 30$: QPSK symbols, $L = P = 2$, $R = 4$ (On the uniqueness bound).
- Comparison between performance of BFM Blind Receiver, MMSE (Non-Blind) Receiver, and Semi-Blind Receivers (either $H$ or $A$ known).

**Conclusion**

The Block Factor Model leads to a powerful blind receiver for multi-user access in wireless communications, with performance close to the MMSE receiver.

Both ISI and multi-path propagation are taken into account. Other methods [1,2] have been developed to improve the convergence speed of the ALS (Levenberg-Marquardt, Line Search, ...).

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