Channel parameter estimation using ISIS algorithm in environment with slightly distributed sources

1 Introduction/Background

A high resolution channel parameter estimation algorithm has been developed by the professional group "Digital Communications" in collaboration with the company Elektrobit AG, Switzerland. It is named ISIS algorithm where the acronym ISIS stands for "Initialization and Searching Improved Space-alternating generalized expectation maximization" algorithm. In recent publications (Fleury et al., 2002b), (Fleury et al., 2002c) and (Fleury et al., 2003), the ISIS algorithm is proposed for joint estimation of the relative delay, the direction (i.e. azimuth and co-elevation) of departure and the direction of incidence, the Doppler frequency as well as the complex polarization weights of waves propagating from the transmitter (Tx) site to the receiver (Rx) site in mobile radio environments.

2 Project description

Diffuse scattering cluster refers to the situation where multi-path waves have very close characteristics in direction, propagation delay and Doppler frequency. A group of such scattering signals is called in our analysis a slightly distributed source. The current SAGE algorithm is developed based on single-source model, which means that the individual propagation paths are assumed to be single waves. It is obvious that this single wave model does not match the slightly distributed source scenario. Due to the model mismatch, when the received signal results from slightly distributed sources, the SAGE algorithm will return multiple single paths with similar parameters. In even worse cases, the ISIS estimator based on single-source wave model may result at estimate artifacts, so-called phantom paths that actually do not exist in the real environment.

To illustrate the problem, here we present an estimation result which is obtained from an experimental investigation performed in a non-line-of-sight pico-cellular environment described in (Fleury et al., 2003). The measurement setting and the evaluation scenarios are introduced in details in (Fleury et al., 2003) and (Fleury et al., 2002b). Fig. 1 depicts the estimated directions of incidence and directions of departure of 25 paths in form of dots superimposed to panoramic photographs of the surroundings taken from the Rx location. The radius of a dot increases linearly with the power weight expressed in dB. The darkness of a dot codes the estimated relative delay according to the bar reported in the figure.

It can be observed that most of the estimated paths are separable paths with significant difference in their characteristics (in angles or in delay). But some paths, e.g. No.1 to 7, which are estimated to be superimposed, very likely originate from one slightly distributed source. Investigations also show that some of the estimated paths can not be reasonably related to one- and two-bounce scenarios. Those paths could be the estimate artifacts due to the model mismatch.
In the next version of the ISIS algorithm, we expect to be able to extract the property of the slightly distributed source by exploring the nominal parameters and the spread factors, instead of stacking multiple paths with very close parameters. At the same time, the estimate artifacts should be identified and removed.

3 Objective of the project

Some preliminary efforts have been made on approximating the slightly distributed source with different signal modes. Simulation studies show that the model based on first-order Taylor expansion approximation can significantly improve the performance of the ISI-SAGE algorithm in estimating the characteristic of the slightly distributed source. However the fact that this model requires the knowledge of the variance of the spreads, makes it difficult to implement in the real applications. Investigations on incorporating the estimation of the variance of the spreads into the ISI-SAGE algorithm are still open at this moment.

Another topic is regarding the coherent effect between observation snapshots of the received signal in radio environments. It is traditionally believed that those snapshots are either highly coherent or completely noncoherent. These two scenarios correspond to the situations where the path parameters are either deterministic or random variable across the snapshots. Both assumptions are not applicable when the snapshots are partially coherent, which is considered to be the real case in the true situations. Therefore it is important to appropriately model the coherent effect and incorporate it into the parameter estimation.

As a continuity of the investigations in this area, this 8th semester project is supposed to proceed with the researches in slightly distributed source estimation in both theory and implementation in the above mentioned two areas. There will be other issues to be solved as they appear during the progress of the research.
4 Courses strongly related to the project

- Stochastic Processes II (SE).
- Digital Modulation I (SE).

5 Methodology

- 50% theory.
- 50% programming and simulation in Matlab and using the program ISIS developed by Elektrobit AG.

6 Supervisors

Xuefeng Yin, Bernard Fleury.

References


