Time-reversal communications in richly scattering environments

organized by
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Workshop Summary

The ARCC Workshop on Time-Reversal Communications in Richly Scattering Environments marked the first event that brought together applied mathematicians, physicists and communications engineers to examine the opportunities and challenges offered by the so-called high-delay-spread-bandwidth channels (HDSBWCs).

Overall, the workshop was a great success. A well-mixed of participants from all three disciplines had attended. Lectures covered the areas of communication theory and time-reversal (TR) techniques, with treatments on both theoretical and experimental aspects. The primary theme of the workshop was to determine whether TR techniques, which have been successfully applied to imaging and underwater acoustic, are equally applicable to wireless communications. This theme was upheld throughout the discussion sessions.

The main conclusions drawn from the discussions sessions are summarized below. These conclusions also give insights as to how further research on the problem should be directed.

1. For single-antenna communication links, full-rate transmission in a HDSBWC requires a highly complex equalizer to mitigate intersymbol interference (ISI). The spatial focusing gain is also significantly reduced when compared to single-shot transmission. These results make TR techniques unattractive for high-data-rate communications. In contrast, TR techniques can be a potential candidate for communication systems that demand low power consumption but only require low date rate, such as wireless sensor networks. How TR techniques compared with existing technologies for low-power-regime communications is largely an open question.

2. In current code division multiple access (CDMA) communication systems, the possibility of intercepting a signal depends on whether the pseudo-random code sequence that spreads the signal can be found. In TR communications, successful interception hinges on whether the channel between the transmitting source and the listener is known. Since measuring the channel is much more difficult than finding the correct code sequence (as there is only a finite number of code sequences to search), TR communication systems can theoretically attain a higher level of security without the help of upper-layer encryption functions. This is an important advantage that deserves an in-depth investigation.

3. Knowledge of channel state information (CSI) at the transmitter is necessary for TR techniques. It is therefore critical to address the issues of how CSI estimation should be carried out, as well as how performance is affected by the accuracy of CSI.

4. Channel models for HDSBWCs are currently nonexistent. Constructing such models would require conducting a large-scale channel measurement campaign, and would be a critical step towards performance characterization of TR techniques in real propagating environments.

The TR research group at Stanford has started examining some of the above issues. In particular, a channel sounder is expected to arrive in Sept. 2005, which would be used for channel measurements and real-time TR experiments. It is conceivable that outcomes from these investigations would lead to further research gatherings in the near future.

Finally, on behalf of all participants, we would like to thank AIM and NSF for sponsoring the workshop. We would also like to thank the staff at ARCC for their hospitality and their help in making the workshop a success.