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Exploiting Spatial Degrees of Freedom in MIMO Cognitive Radio Systems

Stanford researchers have proposed two learning techniques for MIMO secondary users (SU) to spatially coexist with Primary Users (PU). Today, most of the spectrum is allocated to primary users for exclusive use. The proposed techniques will enable additional secondary users to operate on these frequencies without interfering with licensed users. These techniques also provide a novel spatial division multiple access mechanism for equal-priority MIMO users sharing a common channel.

The advantage of both of the proposed algorithms is that they both can be implemented using only energy measurements. These measurements are independent of the transmission schemes of the secondary user and the primary user. Furthermore, an advantage of the first proposed algorithm, the Blind Null Space Learning (BNSL) algorithm, is that the secondary users do not need any cooperation from the primary users, i.e. the primary user is completely passive. The advantage of the second proposed algorithm, the Closed-Form Blind Null Space Learning (CF-BNSL), is reduced complexity over the first algorithm, at the expense of some minimal cooperation from the primary users. This minimal cooperation does not include extra measurements, or any handshake/synchronization with the primary users. In fact, the primary user does not even have to be aware of the secondary user. The proposed techniques will enable the deployment of more wireless communication networks with higher data rates on the same frequencies and area as today.

Upcoming 5G wireless networks are expected to have more antennas at both base stations and mobile terminals. These networks are also expected to have a large number of heterogeneous wireless access points. The need for increased spectral efficiency, as well for simple distributed interference mitigation schemes, makes the

proposed techniques more poignant than ever for commercial systems.

Stage of Research:

- Demonstrated both in theory and simulation that the secondary user can learn via the BNSL or the CF-BNSL algorithm how to avoid interfering with the PU, and that the algorithms converge very quickly
- Both algorithms are being tested on a systems level simulator
- Demonstrated in simulations that in a symmetric MIMO interference channel, this spatial sharing achieves the channel capacity in the high SNR regime

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Applications

- Cognitive radios using MIMO technologies
- Wireless systems as a multiple access technique

Advantages

- Allows secondary users (SU) to utilize primary's (PU's) spectrum with no or minimal cooperation from the side of the PU
- Efficient use of electromagnetic spectrum to allow more wireless communication system at a higher data rate
- Can be implemented using only energy measurements
- Does not require special hardware
- Applicable to many practical communication schemes

Publications

- Goldsmith, Andrea, N. O. A. M. Yair, Alexandros Manolakos, and Konstantinos Dimou. " Exploiting spatial degrees of freedom in multiple input multiple output (MIMO) radio systems." U.S. Patent 9,344,162, issued May 17, 2016.
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Communications 14 (7), 3961-3977, July 2015.
- Y Noam, A Manolakos, AJ Goldsmith, "Null space learning with interference feedback for spatial division multiple access", IEEE Transactions on Wireless Communications 13 (10), 5699-5715, October 2014.
- A Manolakos, Y Noam, K Dimou, AJ Goldsmith, "Blind null-space tracking for mimo underlay cognitive radio networks", Global Communications Conference (GLOBECOM), 2012 IEEE, 1223-1229, December 2012.
- Y. Noam and A.J. Goldsmith, "Exploiting Spatial Degrees of Freedom in MIMO Cognitive Radio Systems," IEEE Int. Conf. on Communications (ICC), 10-15 June 2012.
- Y. Noam and A.J. Goldsmith, "Blind Null-Space Learning for Spatial Coexistence in MIMO Cognitive Radios," IEEE Int. Conf. on Communications (ICC), 10-15 June 2012.

Patents

- Published Application: 20140126666
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Innovators

- Andrea Goldsmith
- Yair Noam
- Alexandros Manolakos
- Konstantinos Dimou

Licensing Contact

Luis Mejia

Senior Licensing Manager, Physical Sciences

Email