interview

Chenhao Qi

"By exploring the joint sparsity of the uplink channel, the pilot overhead can be substantially reduced"

Prof. Chenhao Qi of Southeast University, China, and Columbia University in the US, talks about the significance of the paper 'Uplink channel estimation for massive MIMO systems exploring joint channel sparsity', page 1770.

Tell us about your field of research

My research area lies in multi-antenna wireless communications and sparse signal processing. Typically, base stations (BSs) are equipped with several antennas and each mobile user is served by a single antenna, which makes up a multi-user multi-input multi-output (MU-MIMO) system. The signal processing for both the BS and the users in such a MU-MIMO system is crucially important. We find that by exploring the sparsity of wireless signals, the efficiency of signal processing can be improved and the complexity can be reduced. We started our work on sparse signal processing for multi-antenna wireless communications in 2008, when compressed sensing (CS) technology was proposed and drew great attention in the signal processing community.

Why are you interested in sparse wireless communication?

The popularisation of wireless mobile devices raises demand for high data rate of wireless communications. Nowadays, we use mobile phones and networks that support 4G, such as the time-division duplex (TDD) long term evolution (LTE) or frequency-division duplex (FDD) LTE. However, the data requirement is still unsatisfied due to the rapid development of audio and video services. So what will be the features of 5G? Undoubtedly, the MU-MIMO technology will still be the basis. The METIS, which is the EU flagship 5G project, shows that massive MIMO will be a key technology, where the BS will be equipped with orders of magnitude more antennas that can be even more than the number of served users. Our work will be applied to massive MIMO and therefore the 5G systems.

What have you reported in your Letter?

It is shown in the existing literature that as the number of BS antennas grows to infinity, the additive noise and Rayleigh fading effect will be negligible, leading to very high spectral efficiency and energy efficiency. In such a massive MIMO system working in TDD mode, however, the bottleneck of the performance is the inter-cell interference (ICI) caused by pilot contamination. To mitigate the pilot contamination, one potential choice is to reduce the number of pilots used for the uplink channel estimation. Our research shows that by exploring the joint sparsity of the uplink channel, the pilot overhead can be substantially reduced. We propose a block sparse model where the block coherence is analysed. We also present an algorithm for the model so that a solution can be obtained quickly.

And what is the significance of what you have presented?

With the proposed block sparse model, we can jointly estimate different uplink channels at the BS. Compared to the current method, where the BS makes individual channel estimations for each uplink channel, the joint spare channel estimation can significantly reduce the pilot overhead, supposing that the latter achieves the same channel estimation performance as the former.

How is your group continuing to develop this technology?

We will be working on the sparse signal processing to explore the inherent sparsity of wireless systems, aiming to reduce the complexity as well as to save the temporal and frequency resource. Particularly, we will keep our focus on the design of efficient channel estimation methods to acquire channel state information (CSI) for both TDD and FDD systems. We will study the sparse channel estimation and the pilot optimisation.

What challenges do you expect from this field in the future?

One of the challenges is how to efficiently acquire the CSI of wireless channels so that the optimal or near-optimal beamforming can be achieved. Currently, there are two different modes that massive MIMO systems can work in, including TDD mode and FDD mode. In TDD mode, the downlink CSI can be obtained by uplink channel estimation based on the channel reciprocity. The challenge essentially comes from the ICI caused by the pilot contamination, which is discussed in our paper. In FDD mode, the downlink CSI is first obtained by the users and then fed back to the BS. Therefore the challenge in this mode is the computational complexity of channel estimation and the pilot overhead that grows linearly with the number of channels to be estimated. In massive MIMO systems, the number of wireless links and channels is very large, leading to the proliferation of pilot overhead and thus the reduced resource for data. Also, considering that the mobile users usually use power constrained devices, reducing the complexity of channel estimation for so many wireless links will be a challenging issue.

doi: 10.1049/el.2014.3788