Title of Project / Master Thesis:

Different Topics on Compressed Sensing

Description:

Compressed sensing (CS) is a new universal compression technique, which shifts the complexity of conventional compression algorithms from the encoder to the decoder site. This property is very interesting for applications in which the sensors have very limited resources and cannot apply sophisticated compression algorithms. While audio, image and video compression stand-ards like MP3, JPEG and H265 employ high complexity encoders but rather simple decoders, compressed sensing simply consists of a linear projection of a signal into a low dimensional sub-space, i.e. a vector is multiplied with a fat matrix. This inevitably leads to an underdetermined systems of equations, which cannot be uniquely solved without further side-information. Usually, the solution to be found is sparse, i.e. it has only a few non-zero entries. With overwhelming probability this solution is unique if the measurement matrix has certain properties.

The framework of CS is useful for many applications to reduce the number of required sensors or to decrease the acquisition time while keeping a required quality, e.g. magnetic resonance imag-ing (MRI), seismology, photography (one-pixel-camera).

We offer a variety of student projects, bachelor and master theses in the research area of CS including but not limited to:

- Reconstruction with convex optimization: It has been shown that minimizing the l1-norm of the solution generally leads to a sparse solution and hence, convex optimization techniques can be used to solve the reconstruction. After studying the literature on "Alternating Direction Method of Multipliers" (ADMM), a convex optimization algorithm, shall be implemented and evaluated
- Reconstruction with probabilistic methods: A different approach to recover the solution is based on exploiting prior knowledge of its individual components. The resulting algorithms often perform message passing on graphs. "Vector Approximate Message Passing" (VAMP) belongs to this class of algorithms. It shall be implemented and extended such that it exploits additional structure (block sparsity) in the signal to be detected.

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- Usually, the sensing matrices are randomly drawn from independent Gaussian processes. In spatial modulation systems, however, the sensing matrix is the channel matrix and the propagation conditions determine the sensing matrix. In case of frequency-selective fading, the sensing matrix gets a Toeplitz structure which generally does not fulfill the ususal assumptions. It shall be investigated how the VAMP algorithm performs under these conditions.

All final topics can be adjusted in terms of complexity and expense with respect to the specific requirements of Bachelor and Master theses. Varios aspects can be included into the analysis so that more than 1 thesis can be offered.

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