Master Thesis at TERAKI GmbH

Teraki is a company which specializes on data analytics solutions tailored to the needs of the Internet of Things (IoT). Most of the related applications rely on embedded hardware, restricted battery lifetime, and CPU requirements as well as restricted availability of communication bandwidth. These problem issues recurrently limit the scope of most existing and potential applications. Therefore, software solutions have been developed to reduce the transmitted data volume as well as to address the vast diversity of data sources in the Internet of Things with specialized learning and data processing schemes.
Several applications have been identified in the automotive and Telco market and close collaborations with leading companies in these markets have been already established.

Real-time Analytics

When streaming data, the signal-of-interest is usually acquired within time windows of a predetermined length N, i.e., the acquisition system is adjusted to a block subset of data points out of an infinite dimensional (even continuous) signal. The whole process imposes a minimal delay for the recovery of the full signal, since N data points need to be acquired before they can be estimated. Especially for low frequency sampling of data, this may cause a large delay of several seconds before the data can be recovered again. For example, when gathering temperature data every 5 minutes, it might be necessary to wait up to 50 minutes for the recovery of N=10 data points. Furthermore, block artifacts usually arise at the overlap between subsequent time windows so that the overall reconstruction quality becomes worse.

Several schemes have been proposed and experimentally demonstrated in order to allow for a refresh rate even below the arrival time of a new single data point. For instance, Recursive Compressed Sensing deploys a successive windowing scheme in order to approximate signals in subsequent windows from the previously reconstructed signals. Moreover, as the same data points may be sampled several times within overlapping windows, effective averaging and support detection schemes can be implemented.
Further approaches are based on the Streaming Greedy Pursuit (SGP) scheme and the Streaming Signal Recovery using the l1-homotopy.

Description of the tasks:

- Studying the overall performance of different implementations of real-time compressed sensing regarding overall computational latency, memory requirements and estimation accuracy.
- Potentially developing new algorithmic methods to improve the computational latency and estimation accuracy of the previously named methods; for example, by including novel estimation models or by enhancing the estimation speed and accuracy with recent machine learning schemes.
- The developed scheme could be tested on real-world data and on a hardware implementation.
- Research on various topics at the interface between mathematics, computational science and data analytics.

Requirements:

- Student of mathematics, computer science, physics, or electrical engineering
- Basic programming skills using mathematical modelling languages, such as Matlab/Python/R
- Preferred skills: Experience with Linux operating systems. Experience with at least one additional programming language such as C/Java/Python

Contact:

Daniel Richart
E-Mail: daniel.richart@teraki.com
Tel.: 0176/72837132

Master Thesis at TERAKI GmbH

Teraki is a company which specializes on data analytics solutions tailored to the needs of the Internet of Things (IoT). Most of the related applications rely on embedded hardware, restricted battery lifetime, CPU requirements as well as restricted availability of communication bandwidth. These problem issues recurrently limit the scope of most existing and potential applications. Therefore, software solutions have been developed to reduce the transmitted data volume as well as to address the vast diversity of data sources in the Internet of Things with specialized learning and data processing schemes.
Several applications have been identified in the automotive and Telco market and close collaborations with leading companies in these markets have been already established.

Multiple Measurement Vector (MMV) Sparse Models

In the traditional compressive sensing literature, measurement vectors are modeled as a single measurement vector (SMV), since most of the generated signals have a similar sparsity structure. Therefore, modelling these signals in the same multiple measurement vector model (MMV) is advantageous both in order to reduce the data rates required for a successful recovery and to improve the overall data acquisition and reconstruction speed of the set of signals. In these scenarios, the jointly-sparse measurement vectors are arranged in a matrix and the recovery process is adapted to recover the underlying signal set with the most appropriate joint-sparsity structure. For example, block sparse structures have been shown to exhibit good performance.

Recently, multiple reconstruction schemes have been proposed and demonstrated, such as the MMV-ADM (MMV-Alternating Direction Multiplier), MMVprox, FISTA (Fast iterative shrinkage-thresholding algorithms) as well as matrix completion schemes. However, although their ability to address these MMV problems has been established, their respective performance (overall encoding/decoding latency, estimation accuracy, CPU and memory requirements) and suitability for embedded applications is not fully studied yet.

Description of the tasks:

- Comparison of existing MMV models and reconstruction methods regarding their reconstruction performance, speed, and computational complexity.
- Analysis of optimized MMV representation models covering topics from generalized fusion frames models, including as special cases wavelets/shearlets.
- Potentially developing new algorithmic methods adapted to the chosen models for MMV representation and their complete characterization as well as comparison with state-of-the-art algorithms.
- The developed scheme could be tested on real-world data and on a hardware implementation.
- Research on various topics at the interface between mathematics, computational science and data analytics.

Requirements:

- Student of mathematics, computer science, physics, or electrical engineering
- Basic programming skills using mathematical modelling languages, such as Matlab/Python/R
- Preferred skills: Experience with Linux operating systems. Experience with at least one additional programming language such as C/Java/Python

Contact:

Daniel Richart
E-Mail: daniel.richart@teraki.com
Tel.: 0176/72837132