IRecon – Introducing a Standardized Interface into the Siemens Image Reconstruction Environment

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Introduction: In the recent years, the attention for novel image reconstruction methods, e. g. compressed sensing [1], was very high in the scientific MRI community. Nevertheless, the clinical acceptance of iteratively reconstructed images is widely unknown. One reason for this might be the fact that, up to now, new promising methods have rarely been integrated into a clinical MR scanner which restricted an elaborate evaluation in patients. Although the Siemens image reconstruction environment (ICE) allows collaboration partners to modify the standard image reconstruction pipeline, a standardized interface linking supplementary routines which are implemented in external software libraries has not been available. Therefore, the IRecon interface introduces a standardized way of making new image reconstruction methods available to a clinical evaluation and, furthermore, allows for benchmarking of competitive solutions very easily. The current implementation exemplarily supports two applications implemented in separate external software libraries: 1) a k-t-sparse compressed sensing reconstruction [2] which allows high-resolution cardiac CINE MRI in real-time, 2) a compressed sensing reconstruction for free-breathing whole-heart coronary MRA [3].

Methods: ICE provides the C++ programming framework to implement the image calculation part of any MRI application at a Siemens Magnetom MR scanner (Siemens AG, Healthcare Sector, Erlangen, Germany). The image reconstruction process in ICE is implemented as a pipeline and each element of this pipeline implements one specific operation of the image reconstruction. During a MR experiment, the pipeline and its elements are configured to the specific requirements of the current application. Furthermore, this flexible approach allows for an easy adaptation of the pipeline and, most importantly, new features can be realized without in-depth knowledge of the preceding steps. Last but not least, the framework takes care of meta data, e. g. the slice orientation.

On the one hand, the idea of IRecon, Fig. 1, was to separate the applications logic from the image reconstruction logic, Fig. 2, and, on the other hand, to provide a common interface for different image reconstruction algorithms. Using the IRecon interface, the integration of an existing image reconstruction algorithm, e. g. in a non-proprietary software library, into the ICE framework follows a straightforward procedure in three steps: 1) Compile the existing library as an independent target in ICE. 2) Implement the IRecon interface for each algorithm of this library. 3) Add a call of a new algorithm to the list of implementations already available in the original ICE program. In the final step, an adaptation of the ICE pipeline is required only if a fundamentally new application needs to be supported. After this, simulations with MR raw data are feasible offline and the identical image reconstruction program can be installed at the scanner. Thus, a new algorithm is immediately ready for a clinical evaluation.

```
template <typename DATA>
class IRecon
{
public:
    virtual ~IRecon() {}

    // Configuration
    typedef std::map<std::string, Variant> parameter_map_t;
    virtual ErrorType configure(parameter_map_t& m);

    // Run the algorithm
    virtual ErrorType run(DATA& d) = 0;

protected:
    parameter_map_t m_map;
};
```

Fig. 1: Source code snippet of the IRecon class.

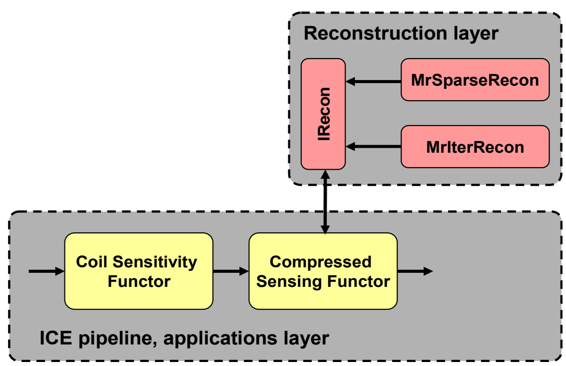

Fig. 2: Detail of the ICE pipeline configured for iterative image reconstruction. The image reconstruction can be switched between competitive solutions, e.g. MrSparseRecon and MrIterRecon, which implement the IRecon interface.

Discussion & Conclusion: IRecon and ICE enable a smooth integration of novel image reconstruction methods into the Siemens system architecture. In this case, there is basically no difference between offline and online processing which allows for optimizing the image reconstruction parameters in a simulation before taking a prototype to the MR scanner. Because ICE supports CPU as well as GPU processing, multiple solutions can be benchmarked easily with respect to e. g. the numerical stability and the image reconstruction speed. Therefore, IRecon seems to be a useful tool to enable elaborate clinical testing of novel image reconstruction methods. This is desperately required in the case of iterative image reconstruction in general and compressed sensing in particular. Finally, the IRecon interface might support the ideas of reproducible research in the field of MR image reconstruction at least to a limited extent.

References:

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