Contribution ID: **57** Type: **not specified**

Fast convolutional resampling on parallel architectures

Monday, 16 October 2017 09:50 (15 minutes)

In radio astronomical interferometry and other applications, the measurements and the image are related by an (approximate) Fourier transform.
In these cases, it is often necessary to resample the measurements onto a regular grid to be able to use the Fast Fourier Transform (FFT).

Resampling includes a convolution to suppress aliasing. The convolution function can also include a correction for deviations of the measurement equation from a Fourier transforms, for example instrumental or atmospheric effects.
Especially for high update rates of the correction, this can become computationally costly.

For LOFAR (and future radio observatories) the data volumes are too large to be send to the end user for further processing.
The data needs to processed at LOFAR central processing.
The processing pipeline needs to run near real time, otherwise an ever growing backlog will arise.
This requirement could not be met when quickly varying corrections for atmospheric effects where included using the conventional approach.

Image Domain Gridding (IDG) is a convolutional resampling algorithm designed from the start to maximize parallelism.
The result is an algorithm that is not the most computationally efficient in pure operation count, but maps very well onto massively parallel architectures. It outperforms other approaches that do fewer compute operations, but are not optimized for parallelism.

Within the DOME project this algorithm has been implemented, optimized and benchmarked for various parallel architectures.

Within the OBELICS project we have analyzed the accuracy of the algorithm, embedded it into an imager for the LOFAR pipeline, and benchmarked the overall performance. Demonstrating that the LOFAR requirements can be met using the GPUs that are part of the LOFAR cluster

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