Technische Universität Chemnitz
Franziska Nestler and Michael Pippig
Jülich Research Center
CECAM Summer School

Programming with Nonequispaced FFT

Lab 1 **Serial NFFT Hands On**

Introduction:
Hint: A pdf version of this worksheet and the solutions are available at http://www.tu-chemnitz.de/~mpip/lehre.php.

Exercise 1: (Installation and testing of NFFT)
Browse through the NFFT homepage

`http://www.tu-chemnitz.de/~potts/nfft`

Then, download the NFFT package [1] and build the library in your home directory, i.e.,

1. `wget http://www.tu-chemnitz.de/~potts/nfft/download/nfft-3.2.3.tar.gz`
2. `tar xzvf nfft-3.2.3.tar.gz`
3. `cd nfft-3.2.3`
4. `./configure`
5. `make`

Lookup and open the source file `simple_test.c` found in `nfft-3.2.3/examples/nfft`. Skim through the subroutine `simple_test_nfft_1d()`. Try to understand what it does. Then, run the actual executable `simple_test`.

Exercise 2: (Exploring precomputation of NFFT)
Using matrix-vector notation as in the lecture, the NFFT algorithm corresponds to using the approximation

$$\mathbf{A}\hat{\mathbf{f}} \approx \mathbf{CFD}\hat{\mathbf{f}},$$

where $\mathbf{C}$ denotes the real $M \times n$ sparse matrix

$$\mathbf{C} := \left(\tilde{\psi}\left(x_j - \frac{l}{m}\right)\right)_{j=0,\ldots,N-1;\, l=-m/2,\ldots,m/2-1}.$$

We propose different methods for the compressed storage and application of the matrix $\mathbf{C}$ which are all available in the NFFT library by choosing different precomputation flags [3, 2]. These methods do not yield a different asymptotic performance but yet lower the constant hidden in the $\mathcal{O}$ notation.

Compare the situation with no precomputation (that is, no precomputation flags set) with the usage of the flags `PRE_PSI` and `PRE_FULL_PSI` in the routine `simple_test_nfft_2d`. Modify the call to `nfft_init_guru` as necessary. Do not forget to execute `make` after every modification. There should be an observeable performance difference. Increase the number of Fourier coefficients of this test case in order to show the run time differences more clearly.

References

[1] Keiner, J., S. Kunis, and D. Potts: *NFFT 3.0, C subroutine library.* http://www.tu-chemnitz.de/~potts/nfft.

[2] Keiner, J., S. Kunis, and D. Potts: *NFFT3.0 - Tutorial to the C library*, 2006. http://www.tu-chemnitz.de/~potts/nfft/guide/nfft3.pdf.

[3] Keiner, J., S. Kunis, and D. Potts: *Using NFFT3 - a software library for various nonequispaced fast Fourier transforms.* ACM Trans. Math. Software, 36:Article 19, 1 – 30, 2009.