Sparse Fast Fourier Transform Code Documentation (SFFT 1.0 and 2.0)

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Abstract

A documentation of the Sparse Fast Fourier Transform (SFFT 1.0/2.0) C++ implementation. The documentation includes a description of the files, the input parameters, the functions and examples of run tests.

1 Introduction

Sparse Fast Fourier Transform (SFFT) is a class of sub-linear time algorithms for computing the discrete Fourier transform of a time domain signal which is *sparse* in the frequency domain, i.e. there are very few "large" coefficients in the frequency domain. The algorithm was presented in [1]. As reported in that paper, experiments with two C++ implementations of the algorithm (SFFT 1.0 and 2.0) demonstrates practical improvement in the runtime over Fast Fourier Transform (FFT) for a wide range of signal sparsities. This papers provides a documentation of the code.

Note: this code is provided for research purposes only. At this stage the code is not a standalone portable library and cannot be used blindly. In particular, it requires setting of several parameters which determine the running time and accuracy of the algorithm. The values of the parameters depend on the signal size and its sparsity. In this documentation we provide example test runs that demonstrate how we set the parameters.

2 License

3 Running the Code

Before compiling and running the code, you must install FFTW version 3.2 or later which can be found at http://www.fftw.org/. You must also install GNUPLOT version 4.2 or later which can be found at http://www.gnuplot.info/. We also recommend reading the paper [1]

The paper describes in details the SFFT 1.0 and 2.0 algorithms. The code has been compiled and tested on Ubuntu 10.04 and 11.10. We provided a make file (GNUmakefile) to compile the code. Table 1 list all the C++ files in the .tar file which are used to compile the code

experiment.cc runs SFFT 1.0 or 2.0 and FFTW and prints out the run times. A description of the input parameters can be found in Table 2. These parameters need to be set differently for each signal size and signal sparsity. The code outputs the time spent in each portion of the code which would allow you to see how each input parameter affects the running time of SFFT. The inputs we used to run our experiments can be found in the file parameters.cc.

generate_graphs.cc is a script that runs SFFT 1.0 or 2.0 and FFTW for a range of signal sizes or signal sparsity and plots the output. The input options to generate_graphs.cc are described in Table 3. Example runs of experiment.cc and generate_graphs.cc can be found in §4.

The code has not been tested for all possible input parameters. We will continue trying to improve the code and the documentation. In the meantime, if you find any bugs or errors, please let us know. All comments and suggestions are most welcome.

File	Description
experiment.cc	Runs sFFT and FFTW once for a set of input parameters. Outputs the runtime of both algorithms and the L1 error of sFFT.
generate_graphs.cc	Runs sFFT and FFTW for a range of parameters and plots the runtime of both verse the signal size (n) or the sparsity (k). Recreates the graphs in the paper: Simple and Practical Algorithm for Sparse Fourier Transform, SODA'12.
kaiserbessel.cc	Plots the time domain and frequency domain response of 3 different filters: 1- Gaussian Filter 2- Dolph-Chebyshev Filter 3- Kaiser-Bessel Filter
computerfourier.h/.cc	Contains the implementation of the sFFT algorithm.
filters.h/.cc	Generates the filters used by sFFT.
utils.h/.cc	Contains the Implementation of standard functions used in the code.
fftw.h/.cc	Contains the FFTW functions.
parameters.h/.cc	Specifies the parameters used to generate the graphs in generate_graphs.cc.
timer.h/.cc	Contains the timing functions used to estimate the runtime of sFFT and FFTW.
plot.h/.cc	Contains functions used to plot the graphs of the filters and runtime results.
fft.h	Contains definitions of the used data types.
GNUmakefile	Make file

Table 1: **C++ Files in the Source Code**

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Option	Variable	Description
-h		Help : Prints the set of options used by the code.
-N	n	Sets the signal size; the total number of frequencies.
-K	k	Sets the signal sparsity; the number of large frequency coefficients.
-R	repetitions	Sets the number of times the experiment is repeated and the result is averaged.
-B	Bcst_loc	Sets the constant for the number of Gaussian filter buckets used to find the locations (support) of the large frequencies. B_loc = Bcst_loc $\times\sqrt{nk/\log n}$
-E	Bcst_est	Sets the constant for the number of Gaussian filter buckets used to estimate the values of the large frequencies. B_est = Bcst_est $\times\sqrt{nk/\log n}$
-l	loc_loops	Sets the number of times we run the Gaussian filter used to find the locations of the large frequencies while permuting the input every time.
-r	threshold_loops	Sets the number of times a frequency coefficient has to appear in the 2×K largest location filter buckets to be considered a large frequency.
-L	est_loops	Sets the number of time we run the Gaussian filter used to find the values of the large frequencies.
-M	Comb_cst	Allows the code to use the Comb filter (i.e. sFFT 2.0 instead of 1.0) and sets the constant for the number of Comb filter buckets. W_Comb = Comb_cst $\times n/$B_loc.
-m	Comb_loops	Sets the number of times the Comb filter is run after permuting the signal.
-S	snr	Specifies the signal to noise ratio.
-A	ALGORITHM1	Avoids using a Gaussian filter to find the locations of the large frequencies only in the case of sFFT 2.0 i.e. loc_loops = 0. It directly estimates the candidate frequencies provided by the Comb filter.
-O	FFTW_OPT	Runs FFTW with optimized FFTW plan.
-t	tolerance_loc	Sets the noise (Leakage) in the Gaussian filter used to find the locations of the large frequencies.
-e	tolerance_est	Sets the noise (Leakage) in the Gaussian filter used to estimate the values of the large frequencies.
-s	simulate	Simulate the expected runtime and error of sFFT without running the full experiment.
-v	verbose	Verbose : prints detailed timing of each step of the code.

Table 2: **Input Parameters to ./experiment**: used to run a single experiment of sFFT

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Option	Variable	Description
-h		Help : Prints the set of options used by the code.
-N	Graph_type	Runs sFFT and FFTW for different values of N and plots the runtime verses N
-K	Graph_type	Runs sFFT and FFTW for different values of K and plots the runtime verses K
-S	Graph_type	Runs sFFT for different signal to noise ratios and plots the error per large frequency verses the SNR
-R	repetitions	Sets the number of times we run FFTW and sFFT with different input for each value of N or K to average the runtime.
-W	WITH_COMB	Run sFFT 2.0 instead of sFFT 1.0 .
-O	FFTW_OPT	Runs FFTW with optimized FFTW plan.
-V	verbose	Verbose : prints detailed timing of each step of the code.

Table 3: **Input Parameters to ./generate_graphs**: used to run a range of sFFT experiments and plot the graphs.

4 Example Test Runs

4.1 ./experiment

1. *SFFT 2.0 (N = 65536, K = 50)*

INPUT: ./experiment -N 65536 -K 50 -B 4 -E 2 -M 128 -m 6 -L 10 -l 4 -r 2 -t 1e-8 -e 1e-8

OUTPUT:

RUNNING EXPERIMENT: n=65536, k=50

Simulation:
****
Projected error rate: 0.000181988 (0.000158854 per large frequency)
Expected running time: 0.0125901
****

sFFT filter parameters for: n=65536, k=50.
****
Comb Filter: loops: 6 mod: 100/8192
Location Filter: (numlobes=1810.0, tol=1e-08, b=47) B: 100/1024 loops: 2/4
Estimation Filter: (numlobes=905.0, tol=1e-08, b=111) B: 512 loops: 10

Window size: Location Filter : 22023; Estimation Filter : 11011;
Noise in filter: Location Filter : 6.22353e-10; Estimation Filter 1.60315e-09
****

sFFT Results
****
Total sFFT time: 0.005218

Time distribution:

scoretable	Comb __	perm+filter	grouping	estimation	stepB+C	other	total
0.000011	0.002111	0.002404	0.000084	0.000203	0.000376	0.000028	0.005218
0.2%	40.5%	46.1%	1.6%	3.9%	7.2%	0.5%	100.0%

ERROR:
K=50; MISSED (estimation, result) = (0, 0); L1 ERROR= 8.84975e-07 (1.76995e-08 per large frequency)
****

FFTW Results
****
Time to create FFTW plan: 0.000397
Time to run FFTW : 0.001631
****

2. SFFT 2.0 (N = 131072, K = 50)

INPUT: ./experiment -N 131072 -K 50 -B 1 -E 1 -M 8 -m 2 -L 12 -l 4 -r 3 -t 1e-6 -e 1e-8

OUTPUT:

RUNNING EXPERIMENT: n=131072, k=50.

Simulation:
****
Projected error rate: 4.5243e-05 (2.83207e-05 per large frequency)
Expected running time: 0.00569716
****

sFFT filter parameters for: n=131072, k=50.
****
Comb Filter: loops: 2 mod: 100/2048
Location Filter: (numlobes=620.0, tol=1e-06, b=279) B: 100/512 loops: 3/4
Estimation Filter: (numlobes=620.0, tol=1e-08, b=325) B: 512 loops: 12

Window size: Location Filter : 5725; Estimation Filter : 7543;
Noise in filter: Location Filter : 6.14223e-08; Estimation Filter 1.66259e-09
****

sFFT Results
****
Total sFFT time: 0.003471
Time distribution:

scoretable	Comb __	perm+filter	grouping	estimation	stepB+C	other	total
0.000028	0.000299	0.002197	0.000117	0.000407	0.000392	0.000032	0.003471
0.8%	8.6%	63.3%	3.4%	11.7%	11.3%	0.9%	100.0%

ERROR:
K=50; MISSED (estimation, result) = (0, 0); L1 ERROR= 1.51982e-06 (3.03965e-08 per large frequency)
****

FFTW Results
****
Time to create FFTW plan: 0.000533

Time to run FFTW : 0.003872
****

3. SFFT 2.0 (N = 262144, K = 50)

INPUT: ./experiment -N 262144 -K 50 -B 1 -E 1 -M 8 -m 2 -L 14 -l 5 -r 4 -t 1e-6 -e 1e-8

OUTPUT:

RUNNING EXPERIMENT: n=262144, k=50.

Simulation:
****
Projected error rate: 5.35776e-07 (4.64458e-07 per large frequency)
Expected running time: 0.00868278
****

sFFT filter parameters for: n=262144, k=50.
****
Comb Filter: loops: 2 mod: 100/4096
Location Filter: (numlobes=853.0, tol=1e-06, b=405) B: 100/512 loops: 4/5
Estimation Filter: (numlobes=853.0, tol=1e-08, b=473) B: 512 loops: 14

Window size: Location Filter : 7877; Estimation Filter : 10379;
Noise in filter: Location Filter : 5.61652e-08; Estimation Filter 1.69292e-09
****

sFFT Results
****
Total sFFT time: 0.005048
Time distribution:

scoretable	Comb __	perm+filter	grouping	estimation	stepB+C	other	total
0.000042	0.000460	0.003726	0.000120	0.000201	0.000459	0.000040	0.005048
0.8%	9.1%	73.8%	2.4%	4.0%	9.1%	0.8%	100.0%

ERROR:
K=50; MISSED (estimation, result) = (0, 0); L1 ERROR= 1.47387e-06 (2.94775e-08 per large frequency)
****

FFTW Results
****
Time to create FFTW plan: 0.001045
Time to run FFTW : 0.010581
****

4. SFFT 2.0 (N = 1048576, K = 50)

INPUT: ./experiment -N 1048576 -K 50 -B 0.5 -E 0.5 -M 8 -m 2 -L 12 -l 4 -r 2 -t 1e-6 -e 1e-8

OUTPUT:

RUNNING EXPERIMENT: n=1048576, k=50.

Simulation:
****
Projected error rate: 4.64535e-05 (2.90716e-05 per large frequency)
Expected running time: 0.0119937
****

sFFT filter parameters for: n=1048576, k=50.
****
Comb Filter: loops: 2 mod: 100/16384
Location Filter: (numlobes=809.0, tol=1e-06, b=1710) B: 100/512 loops: 2/4
Estimation Filter: (numlobes=809.0, tol=1e-08, b=1996) B: 512 loops: 12

Window size: Location Filter : 7471; Estimation Filter : 9843;
Noise in filter: Location Filter : 6.06654e-08; Estimation Filter 1.70257e-09
****

sFFT Results
****
Total sFFT time: 0.009578
Time distribution:

scoretable	Comb --	perm+filter	grouping	estimation	stepB+C	other	total
0.000364	0.001647	0.004426	0.000192	0.002502	0.000410	0.000037	0.009578
3.8%	17.2%	46.2%	2.0%	26.1%	4.3%	0.4%	100.0%

ERROR:
K=50; MISSED (estimation, result) = (0, 0); L1 ERROR= 1.33522e-06 (2.67043e-08 per large frequency)
****

FFTW Results
****
Time to create FFTW plan: 0.000155
Time to run FFTW : 0.064975
****

5. SFFT 1.0 (N = 65536, K = 50)

INPUT: ./experiment -N 65536 -K 50 -B 4 -E 2 -L 8 -l 5 -r 4 -t 1e-8 -e 1e-8

OUTPUT:

RUNNING EXPERIMENT: n=65536, k=50.

Simulation:
****
Projected error rate: 0.00105096 (8.29275e-05 per large frequency)
Expected running time: 0.00882512
****

sFFT filter parameters for: n=65536, k=50.
****
Comb Filter: none
Location Filter: (numlobes=1810.0, tol=1e-08, b=47) B: 100/1024 loops: 4/5

Estimation Filter: (numlobes=905.0, tol=1e-08, b=111) B: 512 loops: 8

Window size: Location Filter : 22023; Estimation Filter : 11011;
Noise in filter: Location Filter : 6.22353e-10; Estimation Filter 1.60315e-09
****

sFFT Results
****
Total sFFT time: 0.005804
Time distribution:

scoretable	Comb --	perm+filter	grouping	estimation	stepB+C	other	total
0.000013	0.000000	0.004632	0.000555	0.000113	0.000452	0.000038	0.005804
0.2%	0.0%	79.8%	9.6%	1.9%	7.8%	0.6%	100.0%

ERROR:
K=50; MISSED (estimation, result) = (0, 0); L1 ERROR= 8.77944e-07 (1.75589e-08 per large frequency)
****

FFTW Results
****
Time to create FFTW plan: 0.000440
Time to run FFTW : 0.001747
****

6. SFFT 1.0 (N = 131072, K = 50)

INPUT: ./experiment -N 131072 -K 50 -B 2 -E 1 -L 10 -l 5 -r 4 -t 1e-6 -e 1e-8

OUTPUT:

RUNNING EXPERIMENT: n=131072, k=50.

Simulation:
****
Projected error rate: 0.000191902 (1.47975e-05 per large frequency)
Expected running time: 0.0072311
****

sFFT filter parameters for: n=131072, k=50.
****
Comb Filter: none
Location Filter: (numlobes=1241.0, tol=1e-06, b=139) B: 100/1024 loops: 4/5
Estimation Filter: (numlobes=620.0, tol=1e-08, b=325) B: 512 loops: 10

Window size: Location Filter : 11461; Estimation Filter : 7543;
Noise in filter: Location Filter : 5.14335e-08; Estimation Filter 1.66259e-09
****

sFFT Results
****
Total sFFT time: 0.003615
Time distribution:

scoretable	Comb __	perm+filter	grouping	estimation	stepB+C	other	total
0.000020	0.000000	0.002429	0.000499	0.000190	0.000445	0.000031	0.003615
0.6%	0.0%	67.2%	13.8%	5.3%	12.3%	0.9%	100.0%

ERROR:
K=50; MISSED (estimation, result) = (0, 0); L1 ERROR= 2.18375e-06 (4.36751e-08 per large frequency)
****

FFTW Results
****
Time to create FFTW plan: 0.000528
Time to run FFTW : 0.003883
****

7. SFFT 1.0 (N = 262144, K = 50)

INPUT: ./experiment -N 262144 -K 50 -B 2 -E 0.5 -L 14 -l 4 -r 3 -t 1e-6 -e 1e-8

OUTPUT:

RUNNING EXPERIMENT: n=262144, k=50.

Simulation:
****
Projected error rate: 0.0283436 (0.00170844 per large frequency)
Expected running time: 0.010498
****

sFFT filter parameters for: n=262144, k=50.
****
Comb Filter: none
Location Filter: (numlobes=1706.0, tol=1e-06, b=202) B: 100/1024 loops: 3/4
Estimation Filter: (numlobes=426.0, tol=1e-08, b=947) B: 256 loops: 14

Window size: Location Filter : 15757; Estimation Filter : 5183;
Noise in filter: Location Filter : 4.71541e-08; Estimation Filter 1.68546e-09
****

sFFT Results
****
Total sFFT time: 0.006095
Time distribution:

scoretable	Comb __	perm+filter	grouping	estimation	stepB+C	other	total
0.000041	0.000000	0.003140	0.000791	0.001695	0.000391	0.000035	0.006095
0.7%	0.0%	51.5%	13.0%	27.8%	6.4%	0.6%	100.0%

ERROR:
K=50; MISSED (estimation, result) = (0, 0); L1 ERROR= 1.6241e-06 (3.2482e-08 per large frequency)
****

FFTW Results
****
Time to create FFTW plan: 0.001094
Time to run FFTW : 0.011047

****

8. SFFT 1.0 (N = 1048576, K = 50)

INPUT: ./experiment -N 1048576 -K 50 -B 2 -E 0.5 -L 12 -l 5 -r 4 -t 1e-6 -e 1e-8

OUTPUT:

RUNNING EXPERIMENT: n=1048576, k=50.

Simulation:
****
Projected error rate: 0.000133638 (2.66753e-06 per large frequency)
Expected running time: 0.0173376
****

sFFT filter parameters for: n=1048576, k=50.
****
Comb Filter: none
Location Filter: (numlobes=3238.0, tol=1e-06, b=427) B: 100/2048 loops: 4/5
Estimation Filter: (numlobes=809.0, tol=1e-08, b=1996) B: 512 loops: 12

Window size: Location Filter : 29907; Estimation Filter : 9843;
Noise in filter: Location Filter : 5.9493e-08; Estimation Filter 1.70257e-09
****

sFFT Results
****
Total sFFT time: 0.012825
Time distribution:

scoretable	Comb __	perm+filter	grouping	estimation	stepB+C	other	total
0.000359	0.000000	0.008136	0.003465	0.000191	0.000624	0.000050	0.012825
2.8%	0.0%	63.4%	27.0%	1.5%	4.9%	0.4%	100.0%

ERROR:
K=50; MISSED (estimation, result) = (0, 0); L1 ERROR= 1.40828e-06 (2.81655e-08 per large frequency)
****

FFTW Results
****
Time to create FFTW plan: 0.000215
Time to run FFTW : 0.063955
****

9. SFFT 2.0 (N = 4194304, K = 100)

INPUT: ./experiment -K 100 -B 0.5 -E 0.2 -M 16 -L 12 -l 4 -r 2 -t 1.e-6 -e 1.e-8

OUTPUT:

RUNNING EXPERIMENT: n=4194304, k=100.

Simulation:
****
Projected error rate: 0.0252479 (0.0103216 per large frequency)
Expected running time: 0.0224433
****

sFFT filter parameters for: n=4194304, k=100.
****
Comb Filter: loops: 1 mod: 200/32768
Location Filter: (numlobes=2183.0, tol=1e-06, b=2536) B: 200/2048 loops: 2/4
Estimation Filter: (numlobes=873.0, tol=1e-08, b=7398) B: 512 loops: 12

Window size: Location Filter : 20163; Estimation Filter : 10621;
Noise in filter: Location Filter : 6.34404e-08; Estimation Filter 1.69937e-09
****

sFFT Results
****
Total sFFT time: 0.017701
Time distribution:

scoretable	Comb _-	perm+filter	grouping	estimation	stepB+C	other	total
0.004953	0.001889	0.006912	0.000332	0.002280	0.000665	0.000669	0.017701
28.0%	10.7%	39.0%	1.9%	12.9%	3.8%	3.8%	100.0%

ERROR:
K=100; MISSED (estimation, result) = (0, 0); L1 ERROR= 1.30322e-05 (1.30322e-07 per large frequency)
****

FFTW Results
****
Time to create FFTW plan: 0.000273
Time to run FFTW : 0.292757
****

10. SFFT 2.0 (N = 4194304, K = 200)

INPUT: ./experiment -K 200 -B 0.5 -E 0.5 -M 32 -m 1 -L 8 -l 4 -r 2 -t 1.e-6 -e 0.5e-8

OUTPUT:

RUNNING EXPERIMENT: n=4194304, k=200.

Simulation:
****
Projected error rate: 0.0126673 (0.00386714 per large frequency)
Expected running time: 0.0391682
****

sFFT filter parameters for: n=4194304, k=200.
****
Comb Filter: loops: 1 mod: 400/65536
Location Filter: (numlobes=3087.0, tol=1e-06, b=1793) B: 400/2048 loops: 2/4
Estimation Filter: (numlobes=3087.0, tol=5e-09, b=2092) B: 2048 loops: 8

Window size: Location Filter : 28513; Estimation Filter : 38925;
Noise in filter: Location Filter : 6.27631e-08; Estimation Filter 7.2714e-10
****

sFFT Results
****
Total sFFT time: 0.032355
Time distribution:

scoretable	Comb __	perm+filter	grouping	estimation	stepB+C	other	total
0.004974	0.004702	0.013986	0.000662	0.006413	0.000895	0.000723	0.032355
5.4%	14.5%	43.2%	2.0%	19.8%	2.8%	2.2%	100.0%

ERROR:
K=200; MISSED (estimation, result) = (0, 0); L1 ERROR= 1.68204e-05 (8.41018e-08 per large frequency)
****

FFTW Results
****
Time to create FFTW plan: 0.000275
Time to run FFTW : 0.293198
****

11. SFFT 2.0 (N = 4194304, K = 500)

INPUT: ./experiment -K 500 -B 0.5 -E 0.5 -M 64 -L 10 -l 4 -r 3 -t 1.e-6 -e 0.5e-8

OUTPUT:

RUNNING EXPERIMENT: n=4194304, k=500.

Simulation:
****
Projected error rate: 0.0162385 (0.00733532 per large frequency)
Expected running time: 0.0552345
****

sFFT filter parameters for: n=4194304, k=500.
****
Comb Filter: loops: 1 mod: 1000/65536
Location Filter: (numlobes=4881.0, tol=1e-06, b=1134) B: 1000/4096 loops: 3/4
Estimation Filter: (numlobes=4881.0, tol=5e-09, b=1323) B: 4096 loops: 10

Window size: Location Filter : 45083; Estimation Filter : 61547;
Noise in filter: Location Filter : 6.28306e-08; Estimation Filter 7.28166e-10
****

sFFT Results
****
Total sFFT time: 0.047826
Time distribution:

scoretable	Comb __	perm+filter	grouping	estimation	stepB+C	other	total
0.005091	0.004665	0.028208	0.001733	0.005341	0.001983	0.000805	0.047826
10.6%	9.8%	59.0%	3.6%	11.2%	4.1%	1.7%	100.0%

ERROR:
K=500; MISSED (estimation, result) = (0, 0); L1 ERROR= 0.0001241 (2.48199e-07 per large frequency)
****

FFTW Results
****
Time to create FFTW plan: 0.000275
Time to run FFTW : 0.289307
****

12. SFFT 1.0 (N = 4194304, K = 100)

INPUT: ./experiment -K 100 -B 2 -E 0.2 -L 12 -l 3 -r 2 -t 1.e-6 -e 1.e-8

OUTPUT:

RUNNING EXPERIMENT: n=4194304, k=100.

Simulation:
****
Projected error rate: 1.28365 (0.00564662 per large frequency)
Expected running time: 0.0467662
****

sFFT filter parameters for: n=4194304, k=100.
****
Comb Filter: none
Location Filter: (numlobes=8732.0, tol=1e-06, b=634) B: 200/8192 loops: 2/3
Estimation Filter: (numlobes=873.0, tol=1e-08, b=7398) B: 512 loops: 12

Window size: Location Filter : 80653; Estimation Filter : 10621;
Noise in filter: Location Filter : 6.36166e-08; Estimation Filter 1.69937e-09
****

sFFT Results
****
Total sFFT time: 0.037965
Time distribution:

scoretable	Comb __	perm+filter	grouping	estimation	stepB+C	other	total
0.004968	0.000000	0.012846	0.005474	0.012696	0.001241	0.000740	0.037965
13.1%	0.0%	33.8%	14.4%	33.4%	3.3%	1.9%	100.0%

ERROR:
K=100; MISSED (estimation, result) = (0, 0); L1 ERROR= 8.27891e-06 (8.27891e-08 per large frequency)
****

FFTW Results
****
Time to create FFTW plan: 0.000274
Time to run FFTW : 0.293045
****

13. SFFT 1.0 (N = 4194304, K = 200)

INPUT: ./experiment -K 200 -B 4 -E 0.5 -L 10 -l 3 -r 2 -t 1.e-6 -e 0.5e-8

OUTPUT:

RUNNING EXPERIMENT: n=4194304, k=200.

Simulation:
****
Projected error rate: 0.0655131 (0.000348553 per large frequency)
Expected running time: 0.0729806
****

sFFT filter parameters for: n=4194304, k=200.
****
Comb Filter: none
Location Filter: (numlobes=24699.0, tol=1e-06, b=224) B: 400/16384 loops: 2/3
Estimation Filter: (numlobes=3087.0, tol=5e-09, b=2092) B: 2048 loops: 10

Window size: Location Filter : 228131; Estimation Filter : 38925;
Noise in filter: Location Filter : 6.10003e-08; Estimation Filter 7.2714e-10
****

sFFT Results
****
Total sFFT time: 0.062505
Time distribution:

scoretable	Comb --	perm+filter	grouping	estimation	stepB+C	other	total
0.004915	0.000000	0.037987	0.005714	0.010656	0.002447	0.000785	0.062505
7.9%	0.0%	60.8%	9.1%	17.0%	3.9%	1.3%	100.0%

ERROR:
K=200; MISSED (estimation, result) = (0, 0); L1 ERROR= 1.02338e-05 (5.11688e-08 per large frequency)
****

FFTW Results
****
Time to create FFTW plan: 0.000277
Time to run FFTW : 0.291602
****

14. SFFT 1.0 (N = 4194304, K = 500)

INPUT: ./experiment -K 500 -B 2 -E 1 -L 12 -l 4 -r 3 -t 1.e-6 -e 0.5e-8

OUTPUT:

RUNNING EXPERIMENT: n=4194304, k=500.

Simulation:
****

Projected error rate: 0.000287754 (7.65499e-06 per large frequency)
Expected running time: 0.131251
****

sFFT filter parameters for: n=4194304, k=500.
****
Comb Filter: none
Location Filter: (numlobes=19526.0, tol=1e-06, b=283) B: 1000/16384 loops: 3/4
Estimation Filter: (numlobes=9763.0, tol=5e-09, b=661) B: 8192 loops: 12

Window size: Location Filter : 180351; Estimation Filter : 123105;
Noise in filter: Location Filter : 5.63804e-08; Estimation Filter 7.39351e-10
****

sFFT Results
****
Total sFFT time: 0.111371
Time distribution:

scoretable	Comb __	perm+filter	grouping	estimation	stepB+C	other	total
0.005113	0.000000	0.074155	0.017721	0.007493	0.005910	0.000978	0.111371
4.6%	0.0%	66.6%	15.9%	6.7%	5.3%	0.9%	100.0%

ERROR:
K=500; MISSED (estimation, result) = (0, 0); L1 ERROR= 5.70762e-05 (1.14152e-07 per large frequency)
****

FFTW Results
****
Time to create FFTW plan: 0.000273
Time to run FFTW : 0.298450
****

15. SFFT 1.0 (N = 4194304, K = 50, SNR = inf)

INPUT: ./experiment -K 50 -B 4 -E 0.2 -L 15 -l 3 -r 2 -t 1e-6 -e 1e-8

OUPUT:

RUNNING EXPERIMENT: n=4194304, k=50.

Simulation:
****
Projected error rate: 0.00103322 (5.11769e-06 per large frequency)
Expected running time: 0.0349159
****

sFFT filter parameters for: n=4194304, k=50.
****
Comb Filter: none
Location Filter: (numlobes=12349.0, tol=1e-06, b=448) B: 100/8192 loops: 2/3
Estimation Filter: (numlobes=617.0, tol=1e-08, b=10468) B: 512 loops: 15

Window size: Location Filter : 114061; Estimation Filter : 7507;
Noise in filter: Location Filter : 6.09389e-08; Estimation Filter 1.70111e-09

****

sFFT Results
****
Total sFFT time: 0.030054
Time distribution:

scoretable	Comb __	perm+filter	grouping	estimation	stepB+C	other	total
0.005104	0.000000	0.016014	0.002761	0.003813	0.001362	0.000999	0.030054
17.0%	0.0%	53.3%	9.2%	12.7%	4.5%	3.3%	100.0%

ERROR:
K=50; MISSED (estimation, result) = (0, 0); L1 ERROR= 1.14759e-06 (2.29518e-08 per large frequency)
****

FFTW Results
****
Time to create FFTW plan: 0.000309
Time to run FFTW : 0.295300
****

16. SFFT 1.0 (N = 4194304, K = 50, SNR = 20dB)

INPUT: ./experiment -K 50 -B 4 -E 0.2 -L 15 -l 3 -r 2 -t 1e-6 -e 1e-8 -S 100

OUPUT:

RUNNING EXPERIMENT: n=4194304, k=50.

Simulation:
****
Projected error rate: 0.00103322 (5.11769e-06 per large frequency)
Expected running time: 0.0349159
****

SNR = 99.9788 / 20.00 dB

sFFT filter parameters for: n=4194304, k=50.
****
Comb Filter: none
Location Filter: (numlobes=12349.0, tol=1e-06, b=448) B: 100/8192 loops: 2/3
Estimation Filter: (numlobes=617.0, tol=1e-08, b=10468) B: 512 loops: 15

Window size: Location Filter : 114061; Estimation Filter : 7507;
Noise in filter: Location Filter : 6.09389e-08; Estimation Filter 1.70111e-09
****

sFFT Results
****
Total sFFT time: 0.029995
Time distribution:

scoretable	Comb __	perm+filter	grouping	estimation	stepB+C	other	total
0.005054	0.000000	0.015507	0.003227	0.003896	0.001373	0.000937	0.029995
16.8%	0.0%	51.7%	10.8%	13.0%	4.6%	3.1%	100.0%

ERROR:
K=50; MISSED (estimation, result) = (0, 0); L1 ERROR= 0.307246 (0.00614491 per large frequency)

****

FFTW Results
****
Time to create FFTW plan: 0.000275
Time to run FFTW : 0.295379
****

17. SFFT 1.0 (N = 4194304, K = 50, SNR = 3dB)

INPUT: ./experiment -K 50 -B 4 -E 0.2 -L 15 -l 3 -r 2 -t 1e-6 -e 1e-8 -S 2

OUPUT:

RUNNING EXPERIMENT: n=4194304, k=50.

Simulation:
****
Projected error rate: 0.00103322 (5.11769e-06 per large frequency)
Expected running time: 0.0349159
****

SNR = 1.99962 / 3.01 dB

sFFT filter parameters for: n=4194304, k=50.
****
Comb Filter: none
Location Filter: (numlobes=12349.0, tol=1e-06, b=448) B: 100/8192 loops: 2/3
Estimation Filter: (numlobes=617.0, tol=1e-08, b=10468) B: 512 loops: 15

Window size: Location Filter : 114061; Estimation Filter : 7507;
Noise in filter: Location Filter : 6.09389e-08; Estimation Filter 1.70111e-09
****

sFFT Results
****
Total sFFT time: 0.029786
Time distribution:

scoretable	Comb --	perm+filter	grouping	estimation	stepB+C	other	total
0.005065	0.000000	0.015559	0.002863	0.003900	0.001445	0.000953	0.029786
17.0%	0.0%	52.2%	9.6%	13.1%	4.9%	3.2%	100.0%

ERROR:
K=50; MISSED (estimation, result) = (0, 0); L1 ERROR= 2.32729 (0.0465457 per large frequency)
****

FFTW Results
****
Time to create FFTW plan: 0.000275
Time to run FFTW : 0.291268
****

18. SFFT 1.0 (N = 4194304, K = 50, SNR = 0dB)

INPUT: ./experiment -K 50 -B 4 -E 0.2 -L 15 -l 3 -r 2 -t 1e-6 -e 1e-8 -S 1

OUPUT:

RUNNING EXPERIMENT: n=4194304, k=50.

Simulation:
****
Projected error rate: 0.00103322 (5.11769e-06 per large frequency)
Expected running time: 0.0349159
****

SNR = 1.00033 / 0.00 dB

sFFT filter parameters for: n=4194304, k=50.
****
Comb Filter: none
Location Filter: (numlobes=12349.0, tol=1e-06, b=448) B: 100/8192 loops: 2/3
Estimation Filter: (numlobes=617.0, tol=1e-08, b=10468) B: 512 loops: 15

Window size: Location Filter : 114061; Estimation Filter : 7507;
Noise in filter: Location Filter : 6.09389e-08; Estimation Filter 1.70111e-09
****

sFFT Results
****
Total sFFT time: 0.030106
Time distribution:

scoretable	Comb __	perm+filter	grouping	estimation	stepB+C	other	total
0.005050	0.000000	0.015866	0.002781	0.004032	0.001417	0000960	0.030106
16.8%	0.0%	52.7%	9.2%	13.4%	4.7%	3.2%	100.0%

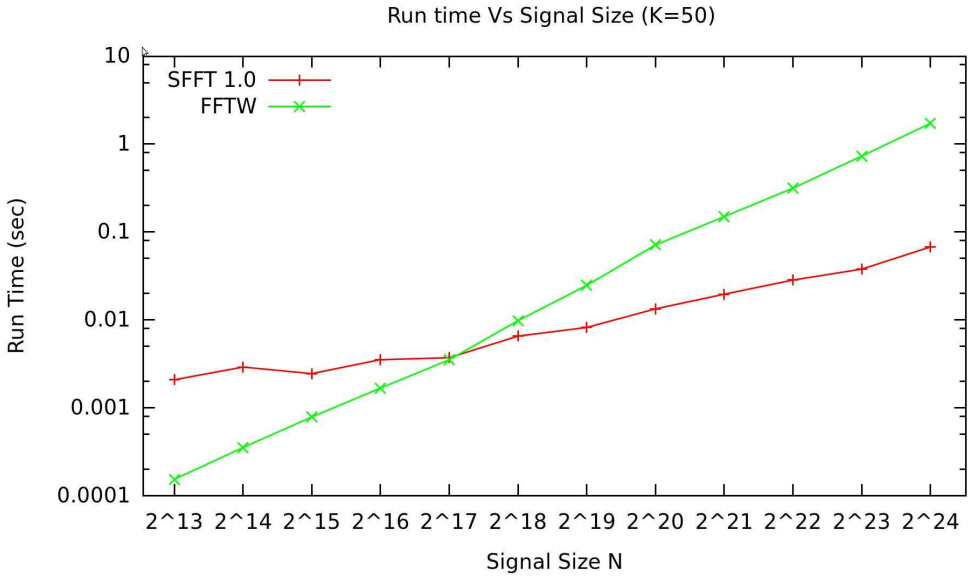
ERROR:
K=50; MISSED (estimation, result) = (0, 0); L1 ERROR= 3.41686 (0.0683372 per large frequency)
****

FFTW Results
****
Time to create FFTW plan: 0.000276
Time to run FFTW : 0.296326
****

4.2 ./generate_graphs

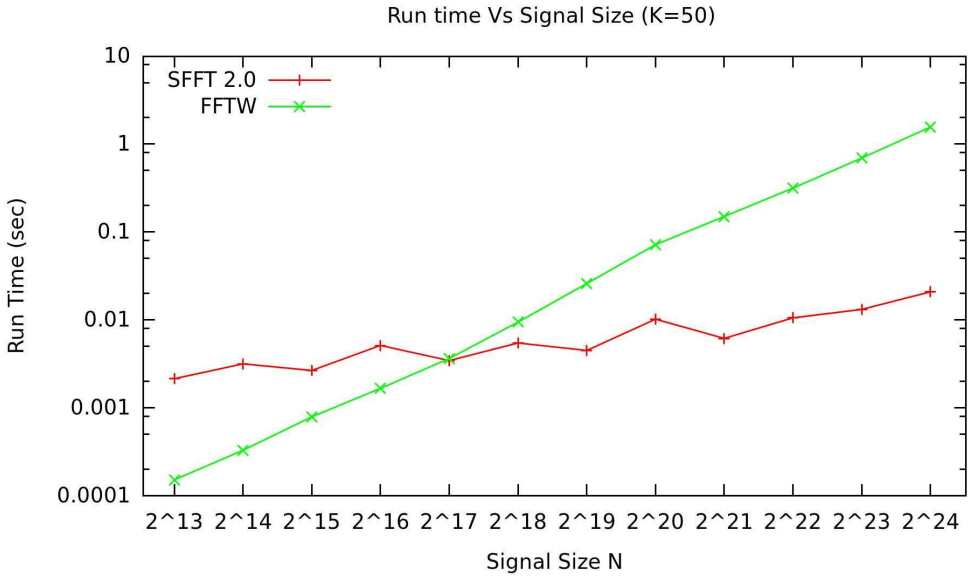
(A) **INPUT:** ./generate_graphs -N -R 10

OUTPUT:



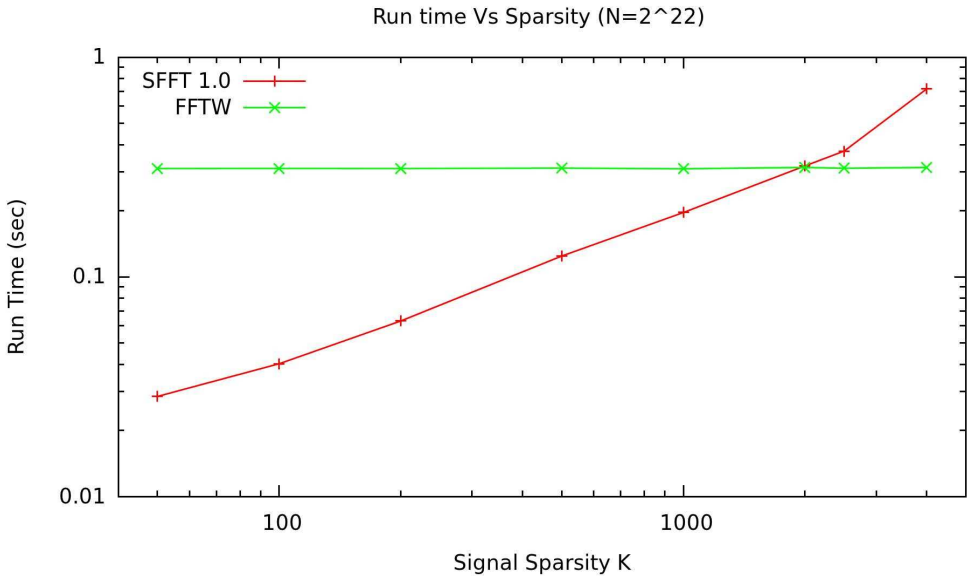
(B) **INPUT:** ./generate_graphs -N -R 10 -W

OUTPUT:



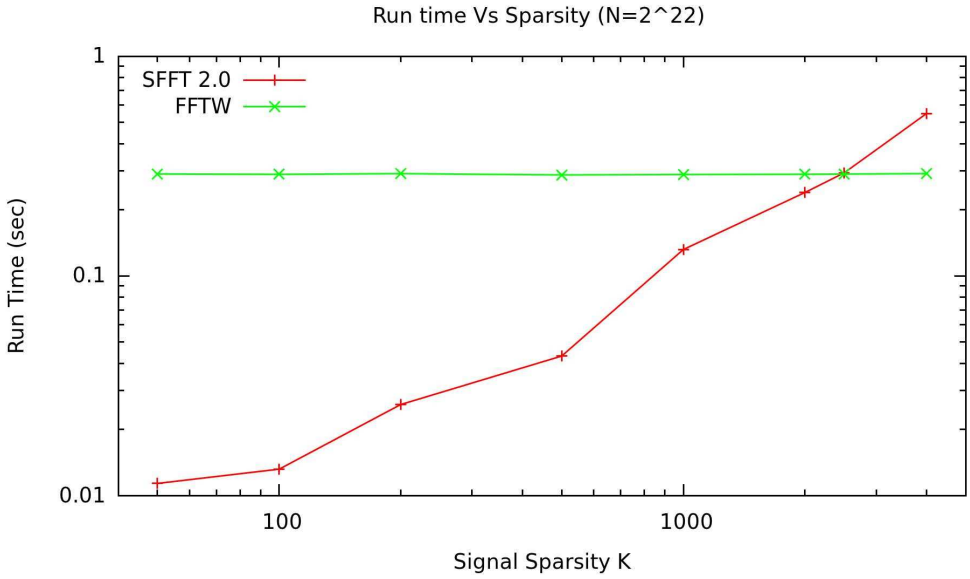
(C) **INPUT:** ./generate_graphs -K -R 10

OUTPUT:



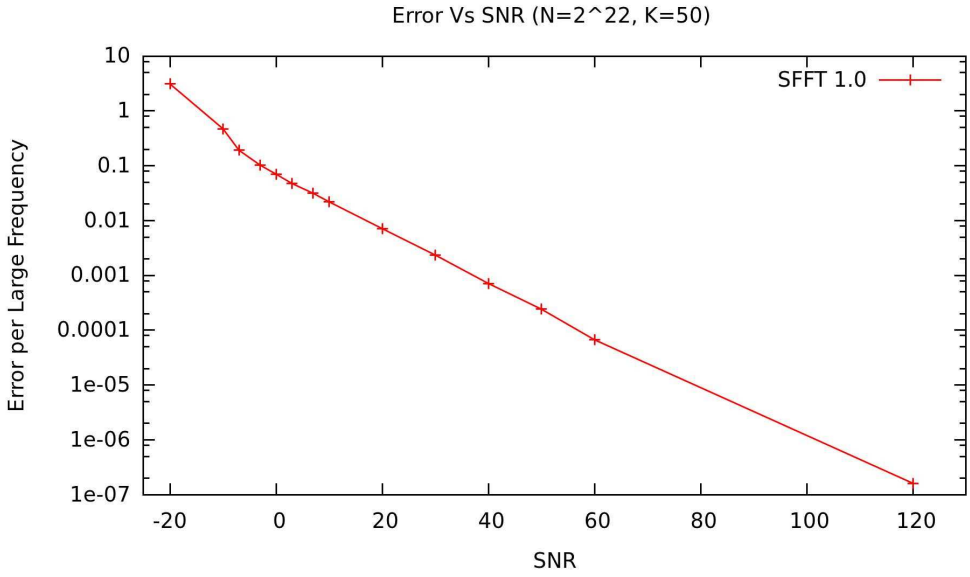
(D) **INPUT:** ./generate_graphs -K -R 10 -W

OUTPUT:



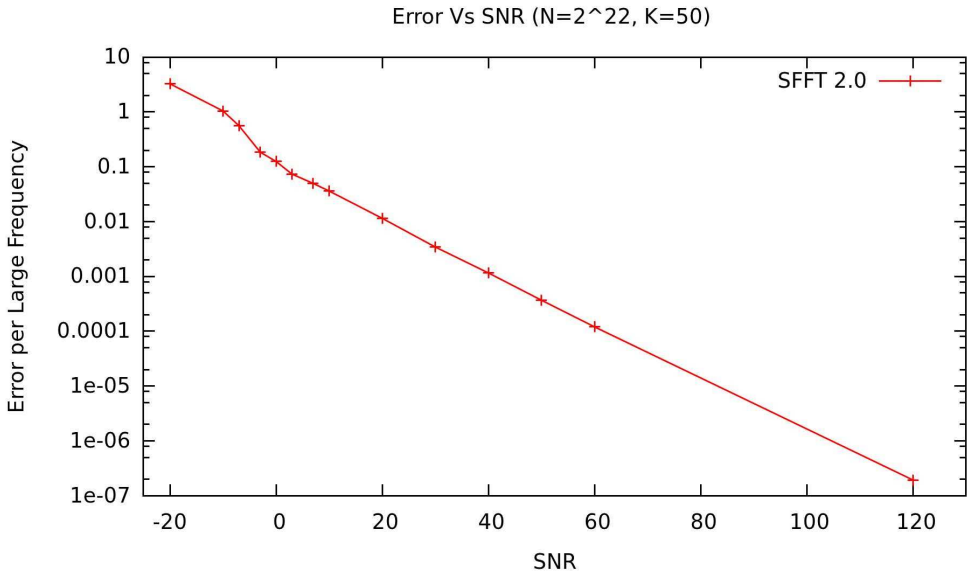
(E) **INPUT:** ./generate_graphs -S -R 10

OUTPUT:



(F) **INPUT:** ./generate_graphs -S -R 10 -W

OUTPUT:



References

[1] H. Hassanieh, P. Indyk, D. Katabi, and E. Price, "Simple and Practical Algorithm for Sparse Fourier Transform", *SODA*, 2012.