In this lab, we used the fft package to study the fast Fourier transform, especially focus on the real to real fft functions and the data storage form .Then we used it in the study of the signal processing. Especially focus on how to use the fft to detect patterns form signal with noises.

This folder contains the following documents:
Makefile: which helps the compilation of the lab.
Fftpack4.cpp: the implementation of fftpack4
Fftpack4.h: the header file of fftpack4.
Fourier.cpp: the main function doing fft
README: the documentation
Report: the report of this lab

To compile and run the code, linux system with g++ compiler is required. The compiler should support the c++ 11 feature.
To compile the code, type make in the terminal.
To run the code, type ./fourier.x
The matlab file can then be used to plot the figures

Code test and output:
The discrete Fourier approximations for n = 16 is:
-9.8696 -6.98122 -3.92561 -1.47536 4.44089e-16 0.531131 0.436179 0.142474 0 0.142474 0.436179 0.531131 4.44089e-16 -1.47536 -3.92561 -6.98122

The discrete Fourier approximations for n = 32 is:
-9.8696 -8.50778 -6.98122 -5.41742 -3.92561 -2.5917 -1.47536 -0.609229 8.88178e-16 0.368546 0.531131 0.535474 0.436179 0.288502 0.142474 0.0378124 0 0.0378124 0.142474 0.288502 0.436179 0.535474 0.531131 0.368546 8.88178e-16 -0.609229 -1.47536 -2.5917 -3.92561 -5.41742 -6.98122 -8.50778

The discrete Fourier approximations for n = 64 is:
-9.8696 -9.21779 -8.50778 -7.75677 -6.98122 -6.19665 -5.41742 -4.65656 -3.92561 -3.23455 -2.5917 -2.00366 -1.47536 -1.01002 -0.609229 -0.273023 8.88178e-16 0.212561 0.368546 0.472836 0.531131 0.549758 0.535474 0.495272 0.436179 0.365074 0.288502 0.212505 0.142474 0.0830094 0.0378124 0.00959187 0 0.00959187 0.0378124 0.0830094 0.142474 0.212505 0.288502 0.365074 0.436179 0.495272 0.535474 0.549758 0.531131 0.472836 0.368546 0.212561 8.88178e-16 -0.273023 -0.609229 -1.01002 -1.47536 -2.00366 -2.5917 -3.23455 -3.92561 -4.65656 -5.41742 -6.19665 -6.98122 -7.75677 -8.50778 -9.21779

n==64 calculate the spectural:
128.103 121.379 71.2142 20.1033 9.77477 5.88189 3.97079 2.88312 2.20236 1.74701 1.42707 1.1936 1.01805 0.882802 0.776517 0.691605 0.622834 0.566502 0.519929 0.48114 0.44865 0.421334 0.398323 0.378943 0.362665 0.349074 0.337844 0.328717 0.321494 0.316023 0.312191 0.309921

Part 2:
The function sample points of clear signal:
0 1.57886 1.9058 1.02262 0.246289 -2.25061 -1.21572 -0.866025 -0.215372 2.62453 0.139129 1.13311 -0.193096 -2.36855 0.866025 -1.60191 0.825886 1.41214 -1.40881 1.95035 -1.34515 -1.24357e-14 1.34515 -1.95035 1.40881 -1.41214 -0.825886 1.60191 -0.866025 2.36855 0.193096 -1.13311 -0.139129 -2.62453 0.215372 0.866025 1.21572 2.25061 -0.246289 -1.02262 -1.9058 -1.57886 -6.47949e-15 1.57886 1.9058 1.02262 0.246289 -2.25061 -1.21572 -0.866025 -0.215372 2.62453 0.139129 1.13311 -0.193096 -2.36855 0.866025 -1.60191 0.825886 1.41214 -1.40881 1.95035 -1.34515 -8.52688e-14 1.34515 -1.95035 1.40881 -1.41214 -0.825886 1.60191 -0.866025 2.36855 0.193096 -1.13311 -0.139129 -2.62453 0.215372 0.866025 1.21572 2.25061 -0.246289 -1.02262 -1.9058 -1.57886 -1.2959e-14 1.57886 1.9058 1.02262 0.246289 -2.25061 -1.21572 -0.866025 -0.215372 2.62453 0.139129 1.13311 -0.193096 -2.36855 0.866025 -1.60191 0.825886

1.41214 -1.40881 1.95035 -1.34515 -7.10605e-14 1.34515 -1.95035 1.40881 -1.41214 -0.825886
1.60191 -0.866025 2.36855 0.193096 -1.13311 -0.139129 -2.62453 0.215372 0.866025 1.21572
2.25061 -0.246289 -1.02262 -1.9058 -1.57886 4.17545e-13 1.57886 1.9058 1.02262 0.246289
-2.25061 -1.21572 -0.866025 -0.215372 2.62453 0.139129 1.13311 -0.193096 -2.36855 0.866025
-1.60191 0.825886 1.41214 -1.40881 1.95035 -1.34515 -1.27906e-13 1.34515 -1.95035 1.40881
-1.41214 -0.825886 1.60191 -0.866025 2.36855 0.193096 -1.13311 -0.139129 -2.62453 0.215372
0.866025 1.21572 2.25061 -0.246289 -1.02262 -1.9058 -1.57886 -2.59179e-14 1.57886 1.9058
1.02262 0.246289 -2.25061 -1.21572 -0.866025 -0.215372 2.62453 0.139129 1.13311 -0.193096
-2.36855 0.866025 -1.60191 0.825886 1.41214 -1.40881 1.95035 -1.34515 -3.1265e-13 1.34515
-1.95035 1.40881 -1.41214 -0.825886 1.60191 -0.866025 2.36855 0.193096 -1.13311 -0.139129
-2.62453 0.215372 0.866025 1.21572 2.25061 -0.246289 -1.02262 -1.9058 -1.57886

calculate the spectural:
1.12994e-13 3.71558e-12 4.08541e-12 2.67895e-12 8.53023e-13 4.35796e-13 5.17446e-13
9.46532e-13 9.05707e-13 1.0991e-12 1.30359e-12 8.53189e-13 1.02497e-12 7.2349e-13 8.64665e-13
6.81633e-13 7.05109e-13 5.79867e-13 8.39223e-14 6.95202e-13 9.15416e-13 4.91418e-13
8.76001e-13 1.36583e-12 8.74769e-13 105 1.19459e-12 1.27439e-12 7.66687e-13 6.49077e-13 105
2.93007e-13 2.39995e-13 1.85909e-13 7.12573e-13 1.16956e-12 1.36726e-13 9.62079e-13
1.51538e-12 1.49428e-12 2.3223e-12 5.72028e-13 1.65684e-12 1.13506e-12 1.5037e-12 6.6241e-13
9.1344e-13 4.82562e-13 8.78759e-13 1.95502e-12 1.53396e-12 4.02606e-13 2.15497e-13
1.21254e-12 1.54197e-13 6.0739e-13 8.90082e-13 4.86455e-13 3.998e-13 1.3653e-12 8.35438e-13
2.26649e-13 1.61094e-12 1.53688e-12 1.0126e-12 2.87379e-13 2.12356e-13 5.68624e-13
2.30335e-13 1.18975e-12 8.57195e-14 2.64402e-12 3.61698e-12 2.55383e-12 5.43842e-13
1.33987e-12 1.4326e-12 2.50788e-13 9.03219e-13 3.36552e-13 105 9.20968e-13 4.93307e-13
1.7568e-13 9.59209e-13 105 3.2868e-13 1.21393e-12 8.03219e-13 1.5255e-12 7.65746e-13
1.0862e-12 2.20931e-12 1.08821e-12 1.74259e-12 5.93593e-13 2.22406e-12 2.68017e-12
6.16813e-13 1.25264e-12 3.25084e-12 3.47196e-12 2.95974e-12 3.00171e-12 6.77765e-12

The function sample points of noize signal:
3.75388 1.82248 1.02307 -0.226136 -1.61156 -1.57573 -2.9637 -0.262434 0.22601 1.70959 -0.817427
1.28866 -3.04585 -3.36621 -0.560703 -2.14401 1.82178 1.00221 0.539058 -0.377565 -3.02582
-2.3074 2.46552 -1.21165 1.09242 -4.31439 -4.90056 -0.0488993 0.0415354 0.206689 -1.79012
-2.62051 -0.786796 -3.21133 -0.200465 1.03947 0.966273 3.84735 -1.61969 0.955752 -2.00253
-0.727755 1.66486 1.68506 2.82394 2.17217 1.0433 -4.05658 0.476515 0.241027 1.58482 2.77261
0.678113 -0.607124 0.943931 -1.49252 0.815743 -0.88085 0.981985 0.0868624 -1.84835 1.65111
1.51408 -1.0682 0.445816 0.231314 1.39092 -0.646222 -3.99977 0.1019 -2.33016 0.511437 1.55404
-0.144536 -2.85105 -1.85848 1.61812 1.53716 1.56281 0.633571 1.28497 -3.42053 -5.52579 -3.56708
1.64841 -1.77943 2.60882 2.08922 1.24674 -2.633 -0.135799 -2.70224 -0.216712 4.88745 -1.11327
4.49811 4.6733 -1.63094 -0.712367 -0.498743 1.35983 1.7675 -1.29022 4.59341 -0.654713 4.66464
-1.30876 -2.65154 2.0653 -5.93813 -0.311264 0.426459 -0.110568 4.08224 0.421419 0.157857
-0.934599 -1.71865 3.6863 2.55462 5.80977 7.42676 -1.73633 -3.38962 -4.72875 3.94131 -0.498908
3.07261 4.01541 0.367848 -3.03312 -0.0874816 -4.20885 0.324878 1.4486 3.03322 0.598278 1.68672
1.56958 1.07928 2.38956 -1.43622 1.26398 0.929529 -3.73585 4.92208 -1.98826 2.50357 -1.55774
-3.13871 2.50388 -1.41983 -1.97172 -2.11673 -0.19702 1.82517 1.51575 -5.05982 0.649928 -3.34447
-0.0589952 -3.34463 -0.954422 -0.269464 -2.23202 -1.572 0.124086 -0.370239 0.899478 1.52325
1.22881 -0.563332 -3.61845 -0.783702 0.843063 0.903039 0.85666 3.74864 0.332903 0.130769
-2.56184 -3.18577 1.7362 0.890218 1.70263 2.11601 0.135535 2.49991 -4.62345 0.810662 1.26428
-0.9384 0.210571 -2.93207 -3.09423 -1.88372 -2.37815 1.47841 2.55553 -1.38494 0.841913 -6.27458
-0.839543 3.05858 1.53055 4.31644 -0.922119 -0.264229 -5.02859 -3.10097

calculate the spectural:
11.3293 49.7313 15.5006 51.4872 12.3823 47.9489 19.4878 13.4672 39.1213 25.4239 39.9594
21.9346 16.0488 26.3399 18.6834 25.789 15.6656 19.6059 4.29294 15.2537 26.0343 41.7403 13.1437
32.6071 40.8389 102.043 49.1215 49.3891 4.50806 39.8515 146.695 17.067 39.7733 23.924 6.42883
41.5033 16.7832 22.5689 37.6337 22.557 7.8769 12.2664 17.8558 32.9092 1.79108 16.836 19.211
16.4275 20.1789 36.7694 25.609 32.2406 26.648 32.1293 34.193 10.2074 29.8581 21.5201 14.1559

16.7136 17.4949 53.1267 5.46642 3.33175 16.5455 22.4948 23.5207 29.2917 15.072 3.39214 21.9971
27.2381 37.7992 21.3512 22.1404 16.1657 16.1307 6.79339 18.827 31.1844 92.9536 13.9819 32.7492
27.0848 43.3426 106.167 28.7924 14.1911 9.75665 12.6946 29.8338 37.4332 8.88406 5.67468
28.1433 28.3141 32.1216 24.8882 35.2523 43.8734 22.8442 19.6312 28.592 24.5897 21.4655