

DFT Using Python

ep17b002

April 2020

1 Abstract

DFT is defined over the space of discrete-time sequences and gives the frequency distribution as a discrete sequence. In this assignment we will be using the `fft` function to examine the frequency domain behaviour of several common functions.

2 My Code

```
1 from numpy import *
2 from matplotlib.pyplot import *
3 from pylab import *
4
5 # 1
6 x=random.rand(100)
7 X=fft.fft(x)
8 y=fft.ifft(X)
9 c_[x,y]
10 print(abs(x-y).max())
11
12 # 2
13 x=linspace(0,2*pi,128)
14 y=sin(5*x)
15 Y=fft.fft(y)
16 figure()
17 subplot(2,1,1)
18 plot(abs(Y),lw=2)
19 grid(True)
20 subplot(2,1,2)
21 plot(unwrap(angle(Y)),lw=2)
22 grid(True)
23 show()
24
25
26 # 3
27 x=linspace(0,2*pi,128)
28 y=sin(5*x)
29 Y=fft.fft(y)
30 figure()
31 subplot(2,1,1)
32 plot(abs(Y),lw=2)
33 ylabel(r"$|Y|$",size=16)
34 title(r"Spectrum of $\sin(5t)$")
35 grid(True)
36 subplot(2,1,2)
37 plot(unwrap(angle(Y)),lw=2)
38 ylabel(r"Phase of $Y$",size=16)
```

```

39 xlabel(r"$k$",size=16)
40 grid(True)
41 savefig("fig9-1.png")
42 show()
43
44 # 4
45 x=linspace(0,2*pi,129);x=x[:-1]
46 y=sin(5*x)
47 Y=fft.fftshift(fft.fft(y))/128.0
48 w=linspace(-64,63,128)
49 figure()
50 subplot(2,1,1)
51 plot(w,abs(Y),lw=2)
52 xlim([-10,10])
53 ylabel(r"$|Y|$",size=16)
54 title(r"Spectrum of $\sin(5t)$")
55 grid(True)
56 subplot(2,1,2)
57 plot(w,angle(Y),'ro',lw=2)
58 ii=where(abs(Y)>1e-3)
59 plot(w[ii],angle(Y[ii]),'go',lw=2)
60 xlim([-10,10])
61 ylabel(r"Phase of $Y$",size=16)
62 xlabel(r"$k$",size=16)
63 grid(True)
64 savefig("fig9-2.png")
65 show()
66
67 # 5
68 t=linspace(0,2*pi,129);t=t[:-1]
69 y=(1+0.1*cos(t))*cos(10*t)
70 Y=fft.fftshift(fft.fft(y))/128.0
71 w=linspace(-64,63,128)
72 figure()
73 subplot(2,1,1)
74 plot(w,abs(Y),lw=2)
75 xlim([-15,15])
76 ylabel(r"$|Y|$",size=16)
77 title(r"Spectrum of $\left(1+0.1\cos\left(t\right)\right)\cos\left(10t\right)$")
78 grid(True)
79
80 subplot(2,1,2)
81 plot(w,angle(Y),'ro',lw=2)
82 xlim([-15,15])
83 ylabel(r"Phase of $Y$",size=16)
84 xlabel(r"$\omega$",size=16)
85 grid(True)
86 savefig("fig9-3.png")
87 show()
88
89 # 6
90 t=linspace(-4*pi,4*pi,513);t=t[:-1]
91 y=(1+0.1*cos(t))*cos(10*t)
92 Y=fft.fftshift(fft.fft(y))/512.0
93 w=linspace(-64,64,513);w=w[:-1]
94
95 figure()
96 subplot(2,1,1)
97 plot(w,abs(Y),lw=2)
98 xlim([-15,15])
99 ylabel(r"$|Y|$",size=16)
100 title(r"Spectrum of $\left(1+0.1\cos\left(t\right)\right)\cos\left(10t\right)$")

```

```

101 grid(True)
102 subplot(2,1,2)
103 plot(w,angle(Y),'ro',lw=2)
104 xlim([-15,15])
105 ylabel(r"Phase of $Y$",size=16)
106 xlabel(r"$\omega$",size=16)
107 grid(True)
108 savefig("fig9-4.png")
109 show()
110
111 # 7
112 t=linspace(-4*pi,4*pi,513);t=t[: -1]
113 y=sin(t)**3
114 Y=fft.fftshift(fft.fft(y))/512.0
115 w=linspace(-64,64,513);w=w[: -1]
116
117 figure()
118 subplot(2,1,1)
119 plot(w,abs(Y),lw=2)
120 xlim([-15,15])
121 ylabel(r"$|Y|$",size=16)
122 title(r"Spectrum of $sin^3(t)$")
123 grid(True)
124 subplot(2,1,2)
125 plot(w,angle(Y),'ro',lw=2)
126 xlim([-15,15])
127 ylabel(r"Phase of $Y$",size=16)
128 xlabel(r"$\omega$",size=16)
129 grid(True)
130 savefig("fig9-4.png")
131 show()
132
133 # 8
134 t=linspace(-4*pi,4*pi,513);t=t[: -1]
135 y=cos(t)**3
136 Y=fft.fftshift(fft.fft(y))/512.0
137 w=linspace(-64,64,513);w=w[: -1]
138
139 figure()
140 subplot(2,1,1)
141 plot(w,abs(Y),lw=2)
142 xlim([-15,15])
143 ylabel(r"$|Y|$",size=16)
144 title(r"Spectrum of $cos^3(t)$")
145 grid(True)
146 subplot(2,1,2)
147 plot(w,angle(Y),'ro',lw=2)
148 xlim([-15,15])
149 ylabel(r"Phase of $Y$",size=16)
150 xlabel(r"$\omega$",size=16)
151 grid(True)
152 savefig("fig9-4.png")
153 show()
154
155 # 9
156 t=linspace(-4*pi,4*pi,513);t=t[: -1]
157 y=cos(20*t + 5*cos(t))
158 Y=fft.fftshift(fft.fft(y))/512.0
159 w=linspace(-64,64,513);w=w[: -1]
160
161 figure()
162 subplot(2,1,1)
163 plot(w,abs(Y),lw=2)
164 xlim([-40,40])

```

```

165 ylabel(r"$|Y|$",size=16)
166 title(r"Spectrum of $\cos(20t + 5\cos(t))$")
167 grid(True)
168 subplot(2,1,2)
169 plot(w,angle(Y),'ro',lw=2)
170 xlim([-15,15])
171 ylabel(r"Phase of $Y$",size=16)
172 xlabel(r"$\omega$",size=16)
173 grid(True)
174 savefig("fig9-4.png")
175 show()
176
177
178 # 10
179 t=linspace(-4*pi,4*pi,513);t=t[:-1]
180 y=exp(-t**2/2)
181 Y=fft.fftshift(fft.fft(y))/512.0
182 w=linspace(-64,64,513);w=w[:-1]
183
184 figure()
185 subplot(2,1,1)
186 plot(w,abs(Y),lw=2)
187 xlim([-15,15])
188 ylabel(r"$|Y|$",size=16)
189 title(r"Spectrum of $\exp(-t^2/2)$")
190 grid(True)
191 subplot(2,1,2)
192 plot(w,angle(Y),'ro',lw=2)
193 xlim([-15,15])
194 ylabel(r"Phase of $Y$",size=16)
195 xlabel(r"$\omega$",size=16)
196 grid(True)
197 savefig("fig9-4.png")
198 show()

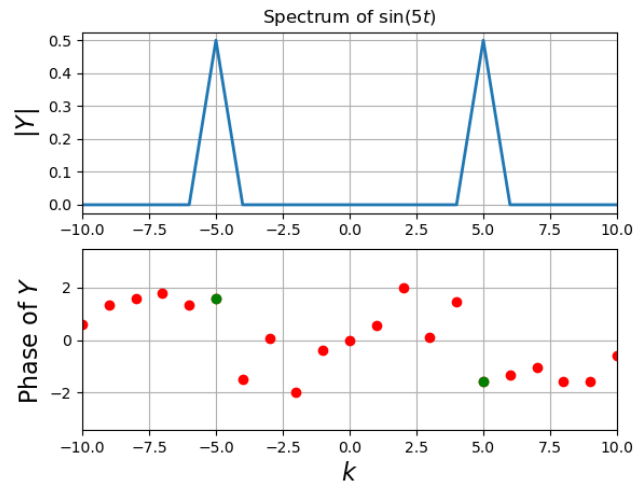
```

3 Plots for the given functions

When we perform FFT and then IFFT on the input data , the error varies from $10^{-16} - 10^{-15}$

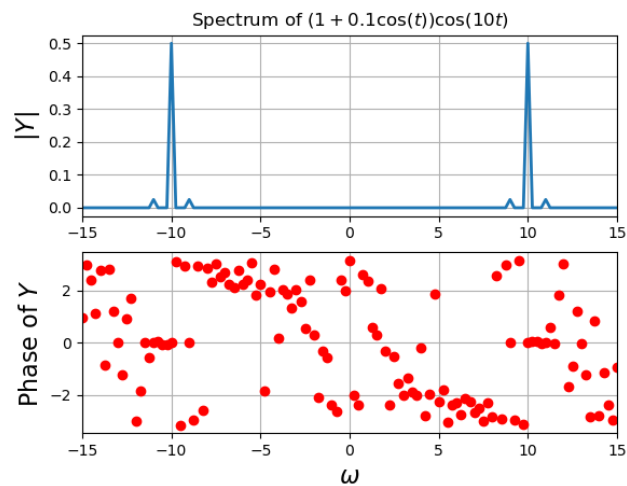
3.1 Question 1

$\sin(5t)$:



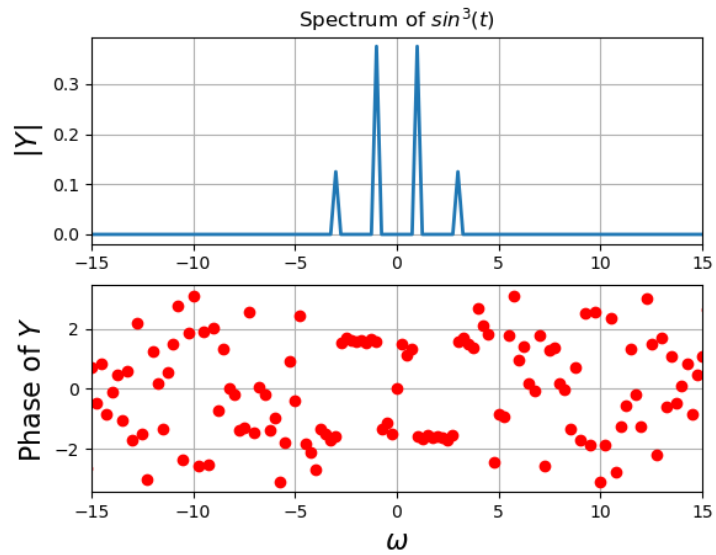
3.2 Question 2

$(1+0.1\cos(t))\cos(10t)$:



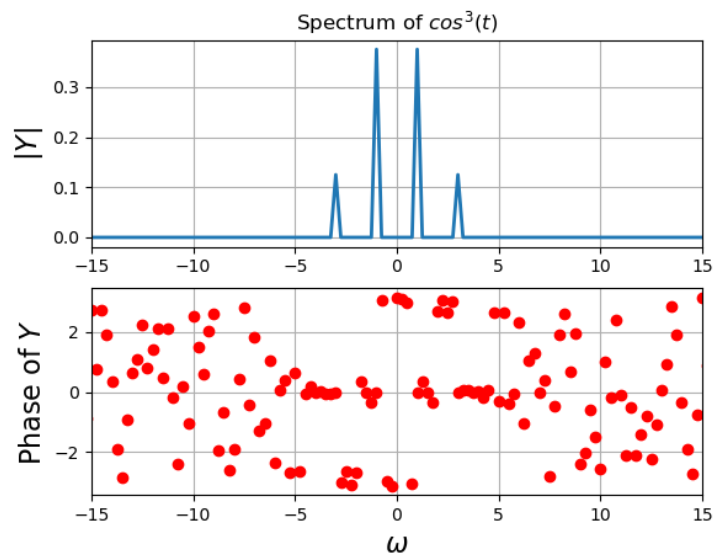
3.3 Question 3

$\sin^3(t)$



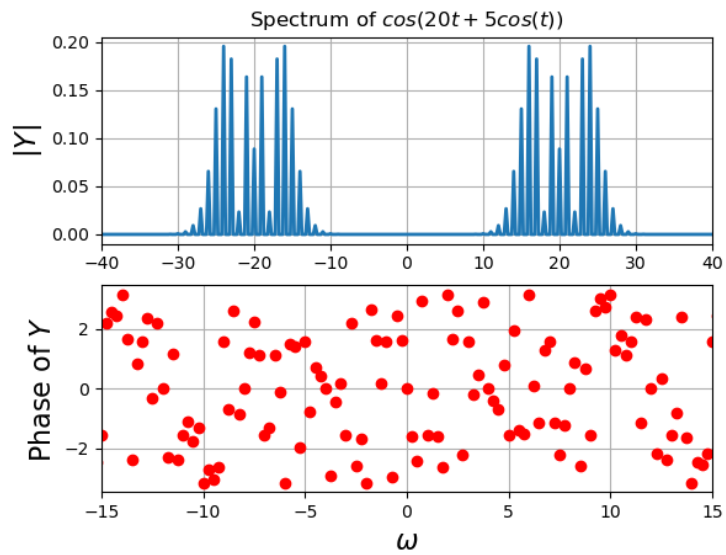
3.4 Question 4

$\cos^3(t)$:



3.5 Question 5

$\cos(20t + 5\cos(t))$:



3.6 Question 6

Gaussian: whose transform is also Gaussian

