MRI Simulator Notes

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Tasks

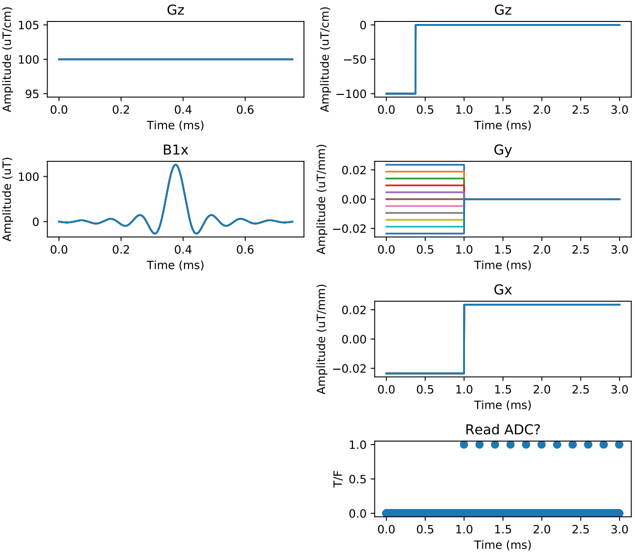
- I wrote a function to generate a 2DFT pulse sequence.
- I wrote a function to reorder the matrix collected from the 2DFT sequence to an order suitable for calling the inverse DFT for image reconstruction.
- I called the simulation and checked the activity monitor.
- I started to write the script for simulating the 2DFT acquisition.

2DFT pulse sequence

Summary

- See the figure on the next slide.
- The left column shows the excitation pulse.
- The right column shows the set of k-space sampling pulses. The only difference between the sampling pulses is the amplitude of G_y to change the line height in k-space.

2DFT pulse sequence example



Comments

- The basic shape of each waveforms looks as expected.
- I am not sure what realistic values are for the various parameters – maybe this is something we can discuss?

Matrix reordering function

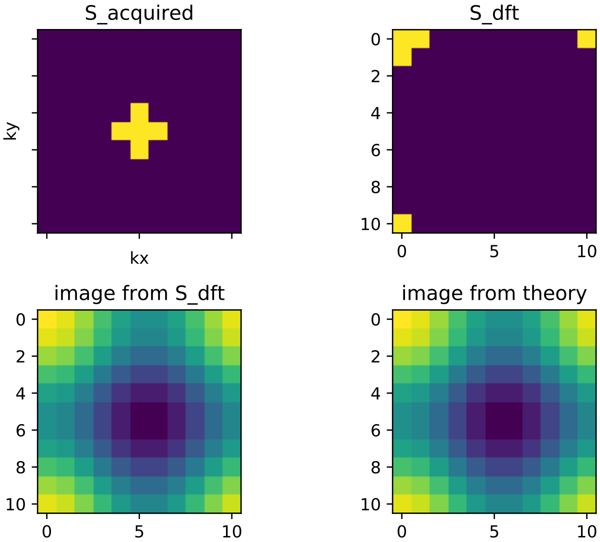
Summary

- I computed the DFT of

$$f(m,n) = 1 + \cos((2\pi/N)m) + \cos((2\pi/N)n)$$

  with $N = 11$ and $m, n = 0, \ldots, N-1$ using negative frequencies to generate the matrix *S_acquired* (DC value at centre of matrix, etc.)
- I computed *S_dft* from *S_acquired* using the `shift_2DFT` function I wrote.
- I compared the image generated this way to $f(m,n)$ (image from theory).

Test results

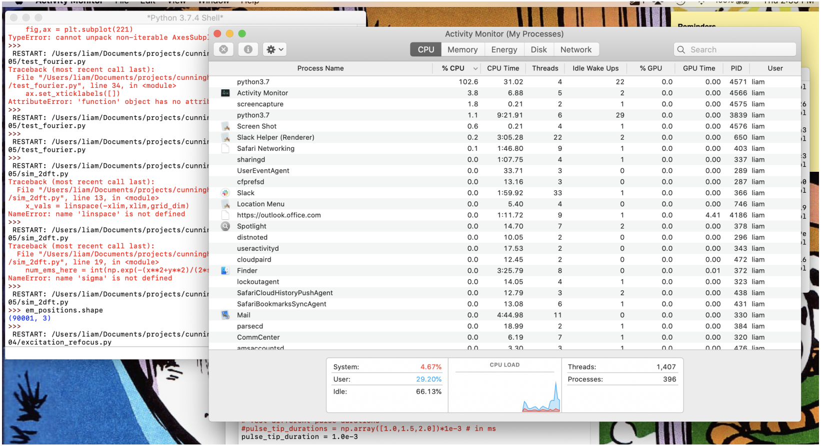


Activity monitor

Summary

- My MacBook has 2 cores.
- I ran the excitation simulation from 2019-12-04 and checked the activity monitor.
- The Python CPU usage exceeds 100%.

Screenshot


Python 3.7.4 Shell
fig,ax = plt.subplot(221)
TypeError: cannot unpack non-iterable AxesSubp
>>>
RESTART: /Users/liam/Documents/projects/cunnir
05/test_fourier.py
Traceback (most recent call last):
File "/Users/liam/Documents/projects/cunningh
/test_fourier.py", line 34, in <module>
ax.set_xticklabels([])
AttributeError: 'function' object has no attrib
>>>
RESTART: /Users/liam/Documents/projects/cunnir
05/test_fourier.py
>>>
RESTART: /Users/liam/Documents/projects/cunnir
05/test_fourier.py
>>>
RESTART: /Users/liam/Documents/projects/cunnir
05/sim_2dft.py
Traceback (most recent call last):
File "/Users/liam/Documents/projects/cunningh
/sim_2dft.py", line 13, in <module>
x_vals = linspace(-xlim,xlim,grid_dim)
NameError: name 'linspace' is not defined
>>>
RESTART: /Users/liam/Documents/projects/cunnir
05/sim_2dft.py
Traceback (most recent call last):
File "/Users/liam/Documents/projects/cunningh
/sim_2dft.py", line 19, in <module>
num_ems_here = int(np.exp(-(x**2+y**2)/(2*s
NameError: name 'sigma' is not defined
>>>
RESTART: /Users/liam/Documents/projects/cunnir
05/sim_2dft.py
>>> em_positions.shape
(90001, 3)
>>>
RESTART: /Users/liam/Documents/projects/cunnir
04/excitation_refocus.py
Activity Monitor (My Processes)
CPU Memory Energy Disk Network
Search
Process Name % CPU CPU Time Threads Idle Wake Ups % GPU GPU Time PID User
python3.7 102.6 31.02 4 22 0.0 0.00 4571 liam
Activity Monitor 3.8 6.88 5 2 0.0 0.00 4566 liam
screencapture 1.8 0.21 2 1 0.0 0.00 4575 liam
python3.7 1.1 9:21.91 6 29 0.0 0.00 3839 liam
Screen Shot 0.6 0.21 4 1 0.0 0.00 4576 liam
Slack Helper (Renderer) 0.2 3:05.28 22 2 0.0 0.00 650 liam
Safari Networking 0.1 1:46.80 9 1 0.0 0.00 403 liam
sharingd 0.0 1:07.75 4 1 0.0 0.00 337 liam
UserEventAgent 0.0 33.71 3 0 0.0 0.00 289 liam
cfprefsd 0.0 13.16 3 0 0.0 0.00 287 liam
Slack 0.0 1:59.92 33 1 0.0 0.00 366 liam
Location Menu 0.0 5.40 4 0 0.0 0.00 746 liam
https://outlook.office.com 0.0 1:11.72 9 1 0.0 4.41 4186 liam
Spotlight 0.0 14.70 7 2 0.0 0.00 378 liam
distnoted 0.0 10.05 2 0 0.0 0.00 296 liam
useractivityd 0.0 17.53 2 0 0.0 0.00 343 liam
cloudpaird 0.0 12.45 2 0 0.0 0.00 472 liam
Finder 0.0 3:25.79 8 0 0.0 0.01 372 liam
lockoutagent 0.0 14.05 4 1 0.0 0.00 323 liam
SafariCloudHistoryPushAgent 0.0 12.79 3 2 0.0 0.00 438 liam
SafariBookmarksSyncAgent 0.0 13.08 6 1 0.0 0.00 431 liam
Mail 0.0 4:44.98 11 0 0.0 0.00 330 liam
parsecd 0.0 18.99 2 1 0.0 0.00 384 liam
CommCenter 0.0 6.19 7 1 0.0 0.00 320 liam
System: 4.67%
User: 29.20%
Idle: 66.13%
CPU LOAD
Threads: 1,407
Processes: 396
#pulse_tip_durations = np.array([1.0,1.5,2.0])*1e-3 # in ms
pulse_tip_duration = 1.0e-3

Applying relaxation during excitation

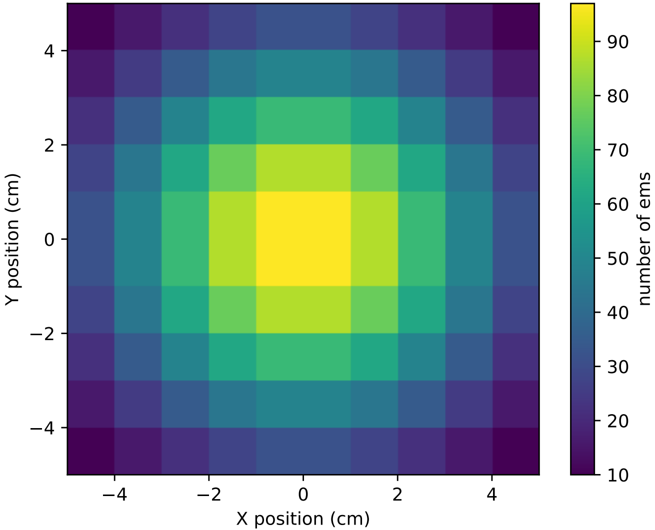
Summary

- Right now, the excitation portion of the simulation represents the effect of each sample of the RF pulse by a rotation quaternion.
- The effect of the entire RF pulse is computed by multiplying all these rotation quaternions together. This is more efficient than multiplying all of the corresponding rotation matrices together.
- This post on Stack Overflow seems to imply that you cannot represent non-uniform scaling (e.g. transverse and longitudinal relaxation) with quaternions; you need to use matrices.
- We can either continue to neglect relaxation during excitation or else I can implement excitation using matrices and incorporate relaxation (the former is more efficient; the latter is more true to the physics).

Script for 2DFT simulation

Summary

- I distributed ems according to a Gaussian curve in x and y as shown in the figure following (with $z = 0$).
- I will try to image this distribution of ems with a 2DFT pulse sequence tomorrow.


4
2
0
−2
−4
Y position (cm)
−4
−2
0
2
4
X position (cm)
90
80
70
60
50
40
30
20
10
number of ems