Computational MRI Worksheet 1

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Reading

Ch.1: 1.1, 1.2, 1.3.1, 1.3.2; the rest is optional

Reading

Ch.2: 2.1.1, 2.2.1, 2.2.2, 2.2.4 and 2.3; the rest is optional

Problem 2.5 (pg 29)

If you don't know how to get started, a hint is provided at the end of the worksheet.

Problems 2.7 (pg 34), and **2.8** (pg 35)

Write a Matlab function to implement the rotation matrix for a rotation about the z axis, and a Matlab script to create an animation of spin precession. Some example codes are provided at the end of the worksheet.

Warning: Hints and Example codes section begins from the next page

Hint for Problem 2.5

$$\frac{d(\mu^2)}{dt} = \frac{d(\overrightarrow{\mu} \cdot \overrightarrow{\mu})}{dt}$$

Example codes for Problems 2.6-2.8

Define the initial spin vector

```
% magnitude in the unit of gamma*h_bar
mu = 1/2;
% set the initial direction in terms of polar and azimuthal angles
% polar angle
theta = pi/6;
% azimuthal angle
phi = 0;
% compute the Cartesian components of the vector
vecMu = mu*[cos(phi)*sin(theta) sin(phi)*sin(theta) cos(theta)]';
```

Visualise the precession in the rotating frame of the Larmor frequency

```
% set the precession frequency relative to the Larmor frequency
% in the unit of radian*kHz
omega = 2*pi;
% set the time increment (in the unit of ms)
deltaT = 0.01;
% set the number of time increments to animate
noOfSteps = 200;
```

Create the subplots for plotting

```
figure;
h1 = subplot(2,2,1);
hold on;
axis equal;
view(100, 10);
xlabel('\mu_x');
ylabel('\mu_y');
zlabel('\mu_z');
xlim([-0.5 0.5]);
ylim([-0.5 0.5]);
zlim([0 0.5]);
```

```
grid on;

h2 = subplot(2,2,2);
hold on;
xlabel('\mu_x');
ylabel('\mu_y');
xlim([-0.5 0.5]);
ylim([-0.5 0.5]);
grid on;
axis square

h3 = subplot(2,2,3);
hold on;
xlabel('time (ms)');
ylabel('\mu_x');
xlim([0, noOfSteps*deltaT]);
ylim([-0.5 0.5]);
grid on;
```

```
% create the 4th plot, with the handle h4, for visualising \mu_y
```

Follow the above example

Create the "clockwise" rotation matrix for one time increment

```
% work out the angle of rotation in one time increment: angle
% create the corresponding rotation matrix: rot
```

Create animation

```
for i=0:noOfSteps-1
      % plot the current vector in figure h1
      % function PlotSpin3D provided below
      hVecMu = plotSpin3D(h1, vecMu);
      % plot the transverse components in figure h2
      hTransverseMu = plotSpinTransverse(h2, vecMu);
```

Follow `plotSpin3D` **example to implement** `plotSpinTransverse`

```
      % plot the x and y components in figures h3 and h4

      % pause
```

```
        pause(0.05);

        % clear the vector and the transverse components
        delete(hVecMu);
        delete(hTransverseMu);

        % plot the current spin vector to keep
        plotSpin3D(h1, vecMu, ['c', 'r'];
        plotSpinTransverse(h2, vecMu, ['c', 'r'];

        % update the spin vector
        vecMu = rot*vecMu;
    end

    plotSpin3D(h1, vecMu);
    plotSpinTransverse(h2, vecMu);
```

Codes for the function `plotSpin3D`

```
function objHandle = plotSpin3D (figHandle, vecMu, colors)
% function objHandle = plotSpin3D (figHandle, vecMu)
%
% a function for plotting the magnetic moment vector of a spin
%
% INPUT:
%
% figHandle - the handle to the figure for plotting
%
% vecMu - the magnetic moment vector (3-by-1) to plot
%
% colors - a 2-by-1 character array: the 1st entry storing the color for
% the stem of the vector, and the 2nd for the tip of the vector
%
% OUTPUT:
%
% objHandle - the handle to the plotted magnetic moment
%
% author: Gary Zhang (gary.zhang@ucl.ac.uk)
%
% for UCL COMP0121: Computational MRI
%

% If the 3rd argument is not provided, set the color vector to some default
% choice
if nargin < 3
    colors = ['b', 'r'];
end

% Plot the stem of the vector
objHandle(1) = plot3(figHandle, [0 vecMu(1)], [0 vecMu(2)], ...
       [0 vecMu(3)], 'Color', colors(1), 'LineStyle', '-', 'LineWidth', 2);

% Plot the tip of the vector
objHandle(2) = plot3(figHandle, vecMu(1), vecMu(2), vecMu(3), ...
       'Color', colors(2), 'Marker', '.', 'MarkerSize', 10);
```