ELEC3810 & BIEN 3310 Homework 4

Please write a short report (within 2 pages) including calculation, figures and attaching codes.

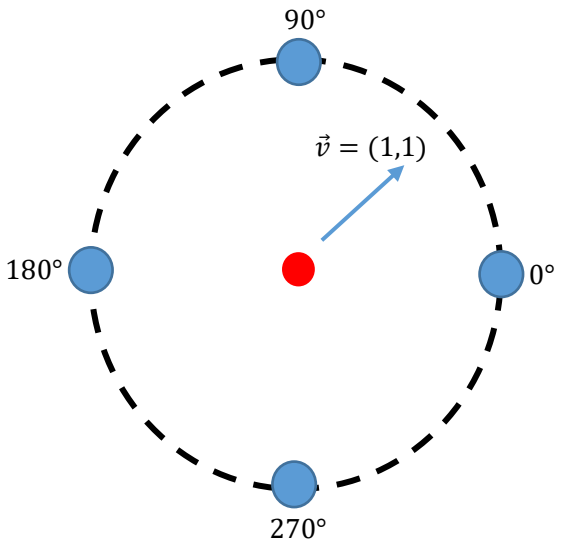
In the process of the reaching movement task (figure below), the neural firing rate will be different in terms of the moving direction. The direction along which a neuron fires maximally is called preferred direction. In order to characterize this phenomena, people have proposed a tuning function as follows:

$$f(\theta) = e^{\kappa \cdot \cos(\theta - \mu)} \quad (1)$$

Here θ and μ represent the angles of movement direction and preferred direction respectively. $f(\theta)$ is the neural firing along the movement direction. κ is a parameter that determines the shape of the tuning function. We can use equation (1) to generate simulated neural firings if we know the movement direction.

On the other hand, if we already know the neural firings, how can we infer the most likely movement direction? One possible way is to use population vector method. Assume there are N neurons in total. We denote the i'th neuron's preferred direction as a vector $\vec{c}_i$, its firing as r_i. Then the movement direction $\vec{v}$ can be decoded by the following equation:

$$\vec{v} = \frac{\sum_{i=1}^{N} r_i \vec{c}_i}{\sum_{i=1}^{N} r_i} \quad (2)$$



In this homework, we assume that the subject has 4 neurons whose preferred directions are $30°$, $120°$, $210°$ and $300°$ respectively. In equation (1), we assume $\kappa = 3$. Answer the following questions.

1. If the moving direction of the subject is $90°$, calculate the simulated spike rate for each of the 4 neurons.
2. If the neural firings of the 4 neurons are $(5,0,12,18)$, calculate the decoded moving direction using the population vector method.
3. Load *ELEC4830_BIEN4310_homework4.mat* file in MATLAB and do the following tasks:

a. The different moving directions (degree) are stored in the variable *movingDirection*. Please generate the simulated spikes for all the moving directions for all the 4 neurons. For each neuron, plot the spike rate in terms of the moving direction to see the tuning curve of each neuron.
b. The neural firings of the 4 neurons are store in the variable *neuralFiring*. The row represents different trials. The column represents the neural firing for the 4 neurons (30°, 120°, 210° and 300°). Please decode the movement direction (vector) for each trial. Store your decoded directions into one matrix named *decodedDirection*. Input this matrix into the given function *plotTrajectory(decodedDirection)* to see the result.