Overview

The aim of this coursework is to produce a report (as a pdf document) which discusses a biological modelling paper. You will be assigned one of four papers to read and, in some cases, a specific parameter whose variation you should consider (see the paper-specific guidance below) The report should begin by introducing the biology of interest; explain how it's modelled, and how it compares to other similar work in the literature; and analyse the dynamics of the model, linking the maths and dynamics back to what the biological system does. The final report should have a flowing storyline which explains the links between the biology and maths, the meaning of the parameters and an interpretation of the resulting system behaviour.

Content

Your report should contain the following content; it will be graded according to the weights indicated.

- Describe and explain the biological system, the model(s), and any pertinent assumptions (10%)
- Perform a literature search, and explain how this model and system compares to others in the literature (15%)
- Simulate the model and plot the state-variables as a function of time, for a set of interesting parameter values. Explain your choice of parameters, describe and interpret the behaviour of the system, and investigate and discuss how the temporal dynamics change as the parameters are varied (20%)
- For your chosen set of interesting parameter values, plot an informative phase-plane at these parameters, which shows off the dynamics of the system. Comment on what the phase planes show, linking back to the biology (20%)
- Create a bifurcation diagram for the system (the free parameter will depend on your system, see the paper-specific guidance below). Discuss the plot, what it shows, and what that relates to in the underlying biological system (25%)
- The report should be structured clearly, and formatted professionally (10%)
- The report must include an AI usage statement, outlining whether you used AI, and if so, how you used it (see below for further details).

It is your choice how to structure the report, but it must contain all the above!

Reports will be marked according to the university marking criteria, available at https://www.bristol.ac.uk/media-library/sites/academic-quality/documents/taught-code/annexes/university-marking-criteria-level7.pdf

General guidance

Remember that there are marks for the quality of the report. As such, all plots should be clear, with axis labels, and have legends where appropriate. It should be clear what parameter values are used for any given plot. The text should form a meaningful and interesting narrative that links the maths and the biology.

A selection of interesting and relevant references should be chosen for your literature search. These should be cited correctly, in your preferred referencing style. There is no target number of references to aim for; rather, you should choose as many or as few as needed to fit your storyline.

You are free to choose your preferred way of analysing the model and producing plots. For example, you can choose MatCont, XPP, CoCo, AUTO, or something else entirely for the numerical continuation. You might choose to export bifurcation diagram data into python or matlab to make plots, or to export the plots straight from XPP or MatCont. Similarly, you can use XPP for generating phase planes, or use your own system (eg. matplotlib / seaborne / plotly / matlab as a plotting engine, quiver plots for flow fields, contour plots at f=0 for nullclines, ODE solvers for trajectories, etc.). Whichever system you choose, the results should be presented clearly and professionally, and must be your own work!

The report should be a maximum of **12 pages (including references)**; note that a well written document of significantly less than this is also acceptable--- this is a strict upper bound, rather than a target! The final report should be submitted as a pdf.

You should also add a short appendix that explains how you have performed your numerical calculations in XPP/Python/Matlab or whichever package you used with sufficient detail to convince the marker that you performed these calculations yourself. The appendix does not count towards the page limit count.

In addition, you should provide a link to a GitHub or other repository for the actual code you generated; this will not be separately marked.

Paper-specific guidance

Below is some additional guidance for each specific paper and theme.

Dupont 1990

You may wish to look here to start your literature review.

Use the parameter β as the free parameter in your bifurcation diagram.

Hasty 2002

You may wish to start your literature review from here.

Your simulations, phase planes, and bifurcation diagrams should use the dimensionless model (page 2 of the PDF).

There are three possible free parameters to use when generating your bifurcation diagram. You should use…

- gamma_x, if you are assigned case 1,
- gamma_y, if you are assigned case 2,
- alpha, if you are assigned case 3.

Morris-Lecar 1981

The paper discusses various models, which have been derived using different assumptions. Make sure to explain these various models and assumptions.

One key assumption is that the calcium dynamics act fast enough to always be at steady-state (manuscript page 13). Your literature comparison should discuss this assumption, and highlight how the resulting model differs from the original Hodgkin-Huxley model.

There are two possible free parameters to use when generating your bifurcation diagram. You should use…

- applied current I, if you are assigned case 1,
- Calcium conductance g_Ca, if you are assigned case 2.

There may be a minus-sign error in the caption of figure 9a; it states that V2 = - 15, but others have suggested it should be V2 = + 15.

Sejnowki 2008

Make sure to discuss the three different excitability classes when discussing the models.

Your literature search should discuss how different excitability classes can affect the dynamics of spike initiation, and the properties of networked neurons; this paper is a good place to start.

Your bifurcation diagram should use applied current I_{stim} as the free parameter.

You should only use one of the three models for your simulations, phase planes, and bifurcation diagram; this will be…

- Class-1 model, if you are assigned case 1,
- Class-2 model, if you are assigned case 2,
- Class-3 model, if you are assigned case 3.

Use of AI

You may only use tools such as spelling and grammar checkers in this assignment, and their use should be limited to corrections of your own work rather than substantial re-writes or extended contributions

Regarding use of AI technology, please refer to Bristol guidelines
https://alt.content.bris.ac.uk/bbcswebdav/courses/Study_Skills/using-ai-at-university/