PROJECTS IN
FRTF01 – PHYSIOLOGICAL MODELS AND COMPUTATION

Instructions

Choose a model of a physiological system from the project list below or from literature, according to your interest. Perform mathematical analysis of the model by means of the concept you have learnt in the course. Also, evaluate its properties with a comparison of published experimental data, if possible. Otherwise you should make a qualitative assessment of the properties of your model by means of simulation. Draw conclusions on the relationships among structure and function. Perform a critical analysis of the model quality and the accuracy.

The articles given in the project list below are only startup material for your projects. You are expected to perform a literature survey on your topic.

The report should be structured as follows:

- Abstract: summary of the the report with purpose, results and conclusions
- Introduction: short background and purpose
- Methods: model, assumptions, analysis method
- Results: simulation results/plots and description of these
- Discussion: discuss the results and relate to the purpose and analysis of quantitative and qualitative behavior
- Conclusions: concluding remarks
- References

Additionally,

- Written using a word processor (Microsoft Word, Open Office, LaTeX, etc), save and send in as a .pdf-file according to the deadlines by e-mail to `FRTF01@list.control.lth.se`.
- If you include figures, make sure they are of good quality. If you take pictures from a book or the internet, make sure they are of good quality as well and that you state the source.

The FRTF01 course project can be done individually or in groups of two students. Make a short project proposal with a work plan and send it to `FRTF01@list.control.lth.se`. for approval by **November 13th**. You will be assigned a supervisor. Make sure you set an appointment with your supervisor to initiate your project. A brief project report on scientific format, as specified above, should be written and sent to `FRTF01@list.control.lth.se`. no later than **December 11th**. A short presentation (5 min) should be given on the project seminar on **December 10th** at 13-15 in M:E. We expect the project to take less than one week of work.

The examination of the FRTF01 projects will result in grades passed or passed with distinction. If your project grade is passed with distinction, the final grade of the course will be raised by one unit. If your exam grade is 3, then your final grade will be 4. If your exam grade is 4, then your final grade will be 5. To reach pass with distinction you must satisfy the following

- Work independently on the project in general and question formulation and Matlab implementation in particular.
- Conduct a novel analysis of the model or implement an extension of it.
- Very well written report.
- More extensive literature survey than otherwise required.

You can talk with your project supervisor about how you are standing on the last three points.

Project Ideas

- **Diabetes pathways**
  - Brian Topp, Keith Promislow, Gerda Devries, Robert M Miura, and DIANE T FINEGOOD. A model of β-cell mass, insulin, and glucose kinetics: Pathways to diabetes. *Journal of theoretical biology*, 206(4):605–619, 2000.
- **IVGTT and diabetes modeling by the minimal model**
  - Cheryl McDonald, Andrea Dunaif, and Diane T Finegood. Minimal-model estimates of insulin sensitivity are insensitive to errors in glucose effectiveness. *The Journal of Clinical Endocrinology & Metabolism*, 85(7):2504–2508, 2000.
- **Modeling circadian oscillations**
  - Quentin Thommen, Benjamin Pfeuty, Florence Corellou, François-Yves Bouget, and Marc Lefranc. Robust and flexible response of the ostreococcus tauri circadian clock to light/dark cycles of varying photoperiod. *FEBS Journal*, 279(18): 3432–3448, 2012.
- **Epidemiological models**
  - N Hohmann and A Voss-Böhme. The epidemiological consequences of leprosy-tuberculosis co-infection. *Mathematical biosciences*, 241(2):225–237, 2013 for epidemiological model of leprosy-turbeculosis co-infection. Extensions of the SIR-model are suitable, for instance in comparison with data from SARS, H1N1 or Ebola epidemics.
  - Collins Bekoe. The sir model and the 2014 ebola virus disease outbreak in Guinea, Liberia and Sierra Leone. *International Journal of Applied Sciences*, 6(2):11, 2015
- **Modeling immune response to tumor growth**
  - Lisette G de Pillis, Ami E Radunskaya, and Charles L Wiseman. A validated mathematical model of cell-mediated immune response to tumor growth. *Cancer research*, 65(17):7950–7958, 2005.

- **Hormonal dynamics**
  - CY Chen and John P Ward. A mathematical model for the human menstrual cycle. *Mathematical medicine and biology: a journal of the IMA*, 31(1):65–86, 2013
- **Optimizing cancer chemotherapy**
  - Athanassios Iliadis and Dominique Barbolosi. Optimizing drug regimens in cancer chemotherapy by an efficacy–toxicity mathematical model. *Computers and Biomedical Research*, 33(3):211–226, 2000.
- **Modeling HIV and immune system dynamics**
  - Eric Jones, Peter Roemer, Mrinal Raghupathi, and Stephen Pankavich. Analysis and simulation of the three-component model of hiv dynamics. *arXiv preprint arXiv:1312.3671*, 2013
- **Immunology and infections**
  - Baris Hancioglu, David Swigon, and Gilles Clermont. A dynamical model of human immune response to influenza a virus infection. *Journal of theoretical biology*, 246(1):70–86, 2007NOTE: Use `ode23` instead of `ode45` to run simulations.
  - Manuel Mai, Kun Wang, Greg Huber, Michael Kirby, Mark D Shattuck, and Corey S O′Hern. Outcome prediction in mathematical models of immune response to infection. *PloS one*, 10(8):e0135861, 2015
- **Alternation of the HH neuron model to model disease or toxin impact**
  - Clay M Armstrong, Francisco Bezanilla, and Eduardo Rojas. Destruction of sodium conductance inactivation in squid axons perfused with pronase. *The Journal of General Physiology*, 62(4):375–391, 1973 for how pronase detroys natrium channel inactivation.
- **Body mass regulation**
  - Joshua Tam, Dai Fukumura, and Rakesh K Jain. A mathematical model of murine metabolic regulation by leptin: energy balance and defense of a stable body weight. *Cell metabolism*, 9(1):52–63, 2009.
- **Predator-prey dynamics**
  - P Kindlmann and AFG Dixon. Insect predator–prey dynamics and the biological control of aphids by ladybirds. In *First international symposium on biological control of arthropods. USDA Forest Service, USA*, pages 118–124, 2003
  - Marat Rafikov and Elizabeth de Holanda Limeira. Mathematical modelling of the biological pest control of the sugarcane borer. *International Journal of Computer Mathematics*, 89(3):390–401, 2012

- **Your own project idea**
  You are welcome to propose your own idea after discussing it with the TA.