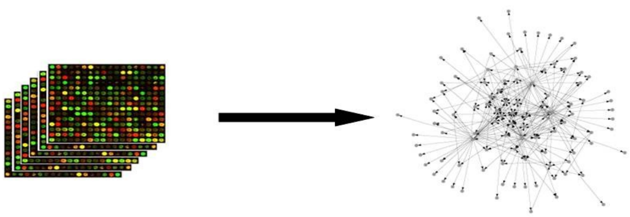
Systems Biology Project 2013

1. Development, analysis and simulations of gene regulatory circuits of Gastrin, Forskulin, HRG and EGF stimuli networks in Cancer research.

Network component analysis (NCA) is a tool that predicts the activity of transcription factors (TF) and their effect on their target genes (TG). Generally, the activity of the TFs is not directly measurable, and these predictions are useful to understand the effect of gene activation and regulation. Genetically circuits that describe the activation and suppression of genes can be developed from NCA analysis and protein protein interaction topology information. This circuits are very important for the understanding of cell regulation in cancer research.

The main goal of the project is to **simulate** various scenarios of the NCA of Gastrin, Forskulin, EGF and HRG stimulated networks. The NCA is a ready-to-use toolbox package in matlab, and the necessary training to use it will be provided.

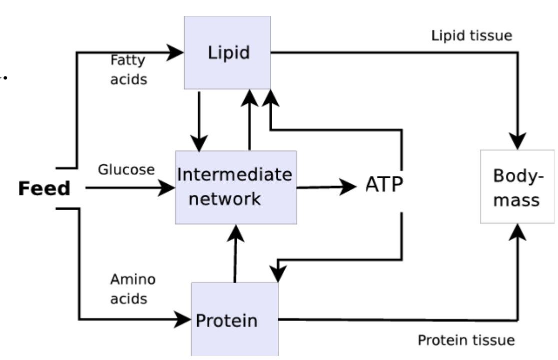


Main Supervisor: Associate Professor Nadav S. Bar

Co-supervisors: Naresh D. J., PhD Candidate, Prof. Lars Imsland, Tek. Cybernetic

2. Simulation and numerical optimization of a dynamic model of growth (System biology: applied modeling)

A novel mathematical model that predicts the growth of fish, given the feed type and environmental conditions, has been developed during 2003-2009. The model traces the nutrients, proteins and fat, through the metabolic processes of the body, and basically it is a set of ordinary differential equations. It was implemented in Matlab code, using a constant time step, first order Euler integration method to solve the differential equations.

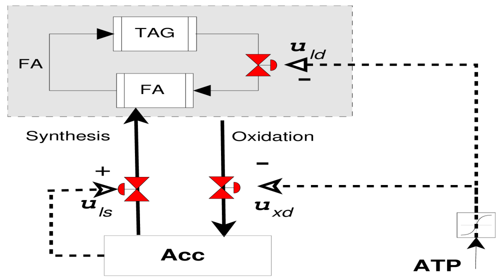


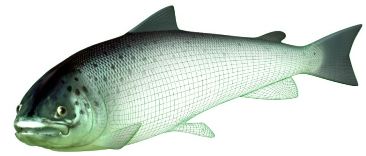
However, this method for solving the differential equations is very inefficient, and a more practical implementation is needed.

The main goal of this project is to optimize the integration method of the model, using a novel, creative combination between a constant time-step and Matlab's ODE time variable solvers (ode45, ode15s). The project is interesting since it attempts to give a practical, industrial, applied solution to a theoretical model. If the program (the implementation of the model) could be optimized and made efficient, it will be of a great value to the aquaculture field, both in study fish development and design more healthy fish feed.

The candidate will learn how to make differential equation solvers more efficient, how to simulate and develop models using ordinary differential equations, a very important aspect of any applied modeling.

Main Supervisor: Assoc. Professor Nadav S. Bar



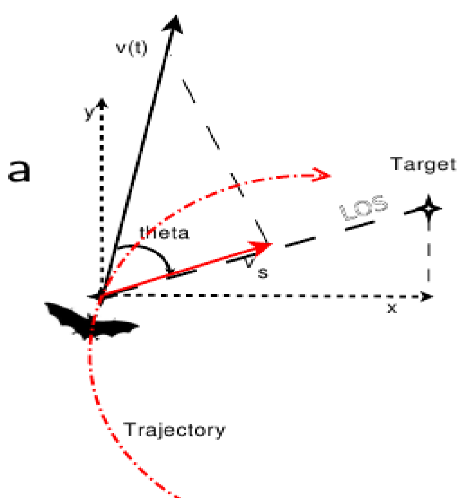


3. Modeling and simulations of bat flight and sonar in 3-dimensions (Systems biology: Neuroscience).

It was found in 2010 (Science Magazine, Yovel et al. 2010) that Egyptian fruit bats apply a sonar measurement strategy that is similar to the strategy used by certain GPS. One of the explanations was that the bat tries to reduce the sonar measurement noise during its flight to the target (which can be fruit or insect).

In our lab (in cooperation with Univ. of Maryland, Weizmann Institute of Science, and the U.S. defence), we developed a dynamic model that estimates the x-y trajectories of the bat's flight as it converges to its target, and explored the strategies it applies to reduce the noise that is reflected from the surroundings (trees, leaves, and other objects around the target). We found that the bat's brain processes the sonar information and filter the noise in a very interesting manner, stems from the fact that the bats has to apply a specific flight control system due to its non-linear flight maneuvers (the bat flies using turbulences, not the common aerodynamics applied by birds).

The main goal of the project is to extend the model (implemented in matlab) to the z- axis as well. It involves modeling of the flight dynamics and the control system, extending it from 2- dimensions to 3-D.



The bat flight, control and filtering is a state space model, implemented and simulated in matlab, and estimated using 145 real time experiments. The project can be later integrated in Master thesis, studying the sonar effect and the flight convergence strategies.

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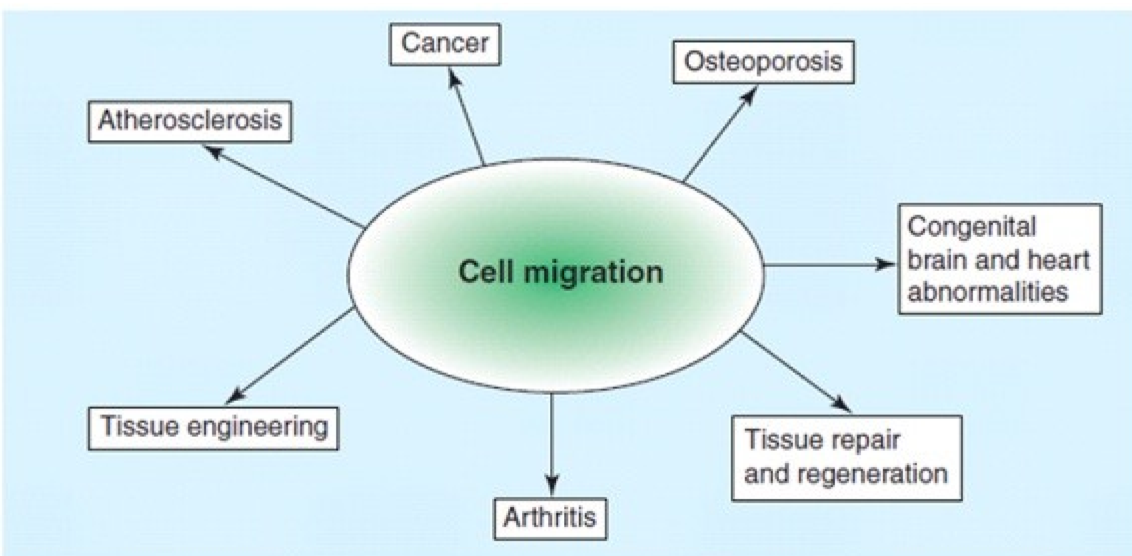
Co-supervisor: Prof. Lars Imsland, Cybernetic

4. The simulations of a dynamic model of cell migration (Systems Biology: Cancer research)

Cell migration is one of the syndromes caused by cancer. During cancer development, the cell grows uncontrollably, the apoptosis (cell's self destruct mechanism) is suppressed, cell proliferation (the cell's devision and multiplication) is accelerated. The defective cells, forming eventually a tumour, tend also to migrate, such that the tumour spreads faster.

We developed a simplified dynamical model of the response of cell migration to the hormone gastrin, a central hormone which is involved in stomach and intestines cancers, deadly and hard to diagnose cancer types. The model is implemented in matlab. We wish te extend the model and explore alternative feedback pathways that can cause the cell to suppress migration. The project aim is to simulate numerous scenarios that can be applied to change the response of cell migration to gastrin.



[1] Horwitz & Webb (2003) Current Biology, 13(9): R756-R759