MATH RESEARCH WEEKEND

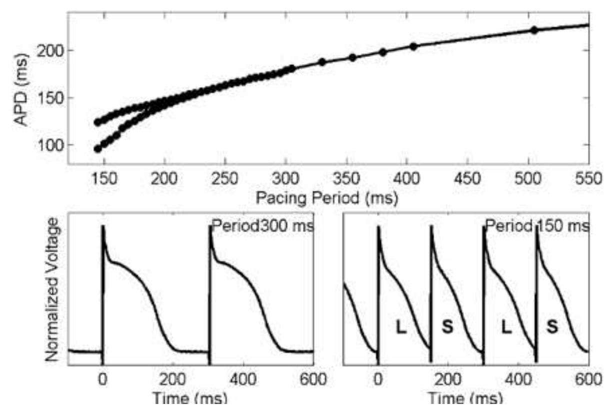
February 1-2, 2019

Department of Mathematics, SUNY Geneseo

Dr. Elizabeth Cherry, RIT

Title: Nonlinear Dynamics of the Heart

Description: The heart is an electro-mechanical system in which, under normal conditions, electrical waves propagate in a coordinated manner to initiate an efficient contraction. Cardiac arrhythmias develop when the propagation of electrical waves through the heart is disrupted. One important type of disruption is the appearance of alternans, a period-two rhythm consisting of alternating long and short electrical signals (action potential duration, APD) that often destabilizes into potentially lethal arrhythmias. Alternans tends to develop at short periods, in the case shown below, it develops for periods below 200ms.



It has been well established that alternans can be driven by instabilities associated with the cell's voltage or intracellular calcium concentration that develop at fast pacing rates. However, most mathematical models that have been developed to study alternans and ways to prevent or terminate it have been analyzed only in the context of the voltage-driven mechanism. Moreover, most of the models that combine the two mechanisms are quite complicated, often including hundreds or thousands of ordinary differential equations or discretized partial differential equations. Such complexity can inhibit understanding of the mechanisms at work.

In this project, we will combine two simple models that have been used separately to describe the voltage and calcium instabilities in cardiac cells and use them to study period-two alternans and higher-order periodic behavior. Each model consists of a single nonlinear difference equation (somewhat like the logistic map); we will couple these two models. Questions to consider include the following:

(i) What fixed points and periodic behavior can occur in the models and what are the stabilities of these dynamics?

(ii) What types of behavior can occur in the coupled models as a function of the coupling and model parameters? In particular, are there conditions under which the coupling may increase or reduce dynamical complexity compared to the behaviors of the uncoupled models?

(iii) How easily can alternans and higher-order behavior be controlled by applying a feedback term to the model? Is the system more sensitive to feedback applied to voltage or calcium? What about other types of control?

(iv) What can happen in a series of interconnected cells?

Come and join Dr. Cherry in this year's MATH RESEARCH WEEKEND (MRW) to learn about the nonlinear dynamics of the heart and get some experience with what mathematical research is all about.

Pre-Requisites: Students should have completed MATH 233 (Linear Algebra I) and MATH 230 (Programming). Students will need Matlab installed on their laptops (to install Matlab go to software.geneseo.edu).

To apply go to www.geneseo.edu/math and look for the link to the online application (Deadline is Jan 30)

Program Schedule:

Friday, February 1	**Saturday, February 2** (South 328)
3:30-4:30 pm: Colloquium Talk in Newton 214	9:00-11:59 am: Second session
4:30-5:00 pm: Pizza dinner (South 328)	12:00-1:00 pm: Lunch
5:00-7:00 pm: First session (South 328)	1:00-4:00 pm: Third session