Creative Inquiry Project: Seeing Cells at Work by Breaking the Optical Resolution Limit

Course Information: BIOE451 Section 6
Credit Hours: 3 hrs
Classroom: 402 Rhodes, Time: Tuesday 4:30-5:30 pm
Laboratory: A212 Rhodes Hall Annex

Instructor: Bruce Z. Gao, Ph.D., Associate Professor of Bioengineering
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OFFICE HOURS: by appointment

Pre-requisite for the course: None (answering questionnaire and by invitation)
Textbook: None

Project Overview: Current biomedical research is focused on the cellular and molecular levels, where optical microscopic techniques play important roles. The resolution of microscopes is limited naturally by its effective orifice for passing the imaging light. Great effort has been made in the optical imaging field to break this natural resolution. We have adapted the temporal focusing technique in our recently developed two photon and second harmonic generation hybrid confocal microscope to increase the axial resolution for investigating the myofibrillogenesis in heart muscle cells. However, the introduction of an optical grating element for achieving temporal focus creates nonlinear confocal scanning process. To obtain accurate imaging with a potential resolution approaching the natural resolution limit enabled by the temporal focusing, it is required that the nonlinear scanning process to be investigated precisely. This creative inquiry project aims to investigate the temporal focus technique via numerical simulation and experimental evaluation.

Anticipated Learning Outcomes: Students will start to master a theoretical-experimental balanced research method. Specifically, students will be able to build hypotheses and address the research questions using computer simulations, as well as to develop laboratory skills that include mechanical and electrical designs, machine shop manufactory, optical system construction, digital signal acquisition and image analysis. They will be requested to present their research data in national conferences (e.g., annual meetings of Biomedical Engineering Society and/or Society for Biomaterials) as undergraduate research competition candidates.

Activities:
Lab
1) Simulate the grating's dispersion process corresponding to different incident angle
2) Develop a nonlinear scanning driving curve in terms of the simulation
3) Design a testing system based on current confocal microscope to test the developed nonlinear scanning curve and correct the theoretical simulation accordingly
4) Repeat procedure 1-3 to optimize the final design

Classroom
1) Oral presentations of related literatures, theoretical analyses, and design plans
2) Sectional and final reports

Grading:

- Attendance (20% of grade); will be taken each class. Attendance is mandatory for all classes. For justified absences, please contact the instructors. Each unjustified absence will reduce the final grade by 3% for each absence (more than 3 unjustified absences will yield a B grade).
- Group efforts (up to 10% of grade) (reports and presentations)
    - Team work is encouraged but more emphasis will be on individual creativity
- Individual efforts (up to 70% of grade)
    - Active class participation
    - Lab reports
    - Lab notebook
    - Individual grades obtained from peers during group presentations
- Proposed bonus activities (up to 10% of grade)
    - Interviews with surgeons and/or patients
    - Conduct surveys on public opinion about medical simulators

Final Exam: None

Drop and Withdrawal: Notify the instructor either by verbally or email of your intension of dropping the course.

Questionnaire

1) Name:
2) Major:
3) Year at Clemson University (as of May 2011): 1st
4) Current Overall GPA:
5) Why are you interested in joining this Creative Inquiry experience?

6) What do you want to do when you graduate and why?

7) How do you rate yourself in time management?
   I think I am 3 (On time mostly)
   Explanation of the choice
   1. Well organized (Have a weekly calendars of things to do, always on time for class and meetings, prepare for class/exams in advance)
   2. Moderately organized (Have a to do list, always on time for class and meetings, try to give myself some time to get things done)
   3. On Time Mostly (Try to show up at class/meetings and get things done on time)
   4. Procrastinator (I wait until last minute to do things)
   5. Total mess (Always late and/or miss deadlines often)