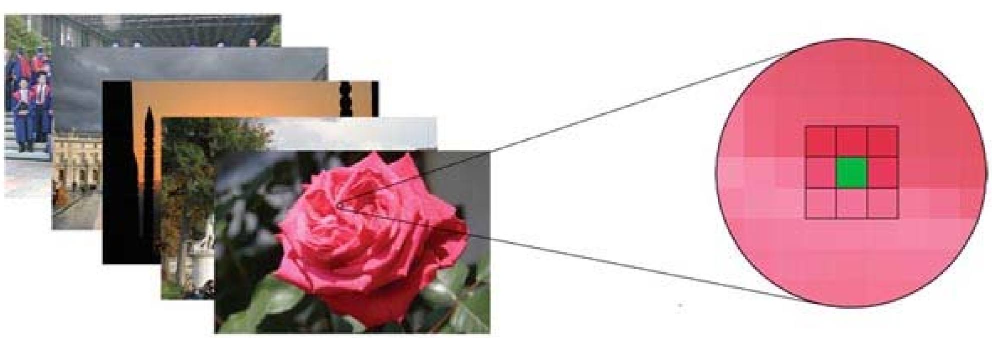
NSERC Summer 2021
Digital Camera Sensors, Optical Chemical Sensors and New Magnetic Field Computation Methods

With Prof. Glenn Chapman (ENSC)
email glennc@cs.sfu.ca
http://www.ensc.sfu.ca/people/faculty/chapman/

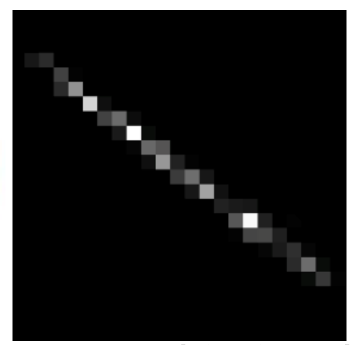
Interested in digital camera research, biomedical imaging through tissue using optics, or getting a hands introduction to how micro-chips and micro-optical sensors are made? Then get some real lab experience from NSERC summer positions which are available in three areas. Depending on the students' there may be more than one student per project. Students selected for these projects will receive a NSERC funding of $8,512. Note these projects are designed so that students can perform the work remotely is Covid 19 restrictions are still in place this summer. The descriptions are below or download this page for a description of all 3 projects.

NSERC Summer Project 1
Helping Improve Digital Camera Sensors

With Prof. Glenn Chapman (ENSC)



Defective pixel effect in digital camera picture



Cosmic Ray path (SEU) created in Digital Camera Sensor

Are you interested in digital photography or optical sensors? Or would you like to make complex chips more reliable? We are exploring ways of ways of improving both digital sensors and regular chips using the CMOS Sensors (Active Pixel Sensors) in Digital Cameras, including cell phone cameras. There three areas we are working on: the identification of permanent defects as cameras age, the creating new ways to recover the missing pixel information and using these camera sensors to identify regular chip defects called Single Event Upsets (SEUs). As the digital camera sensors become larger, but their pixels become smaller, the probability of pixel defects increases over the lifetime of the sensor. These defects in both cameras and regular chips is Cosmic Rays, particle radiation from outer space that hits the earth. When these high energy particles hit microchips they create either temporary defects (Single Event Upset) that cause the chip to give wrong computations, or if really high energy, permanently damage the chip (see images above). In cameras these cause defective or dead pixels. People do not want to throw away expensive cameras just because they have dead pixels in it, but find such dead spots annoying in pictures. In chips the SEUs create real problems in real time systems such as encryption. Digital cameras let us explore both the temporary (SEU) and permanent effects of this radiation on microchips. Previous students have also been part of published conference papers on these results and part of it has resulted in a patent application.

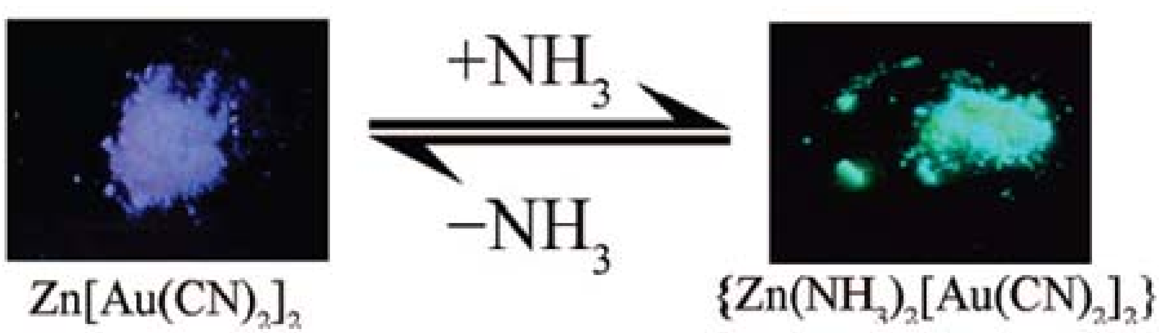
Depending on the student's background this project would range from:
(1) Experimental testing of digital cameras to identify and evaluate defects. This can include hardware development for the testing, and software development to run the tests (controlling the cameras).
(2) Developing software programs to analyze the image data to locate the defects, and extract their parameters.
(3) Developing algorithms and software for recovering the true image hidden by the defect.
(4) Experimental testing of already fabricated chips with new Active Pixel Sensor designs. This includes both optical, and electronic measurements
(5) The design of new pixel cells (if they have a taken ENSC 450 VLSI design)
Previous summer students have also been part of published conference papers on these results (including one that is part of a patent application), and the project can be expanded into a BASc thesis. 40% of the students working on NSERC summer projects in this group have gone on to win NSERC graduate scholarships, in part aided by their research.

Skills Needed:
Student should be in third year or above. Some combination of the following skills are needed, but not all are required (i.e. if you have all but 470, 460 or 450 that is fine). The skill set will determine the type of project. If you at taking these courses below in spring 2011 that is fine.

(1) A background in digital photography is very helpful, and a general liking of experimental work.
(2) Experience with adobe photoshop, or digital raw files valuable
(3) Good computer skills, Spreadsheets & Matlab and/or C programming very helpful.
(4) Taken an Optics courses: Optical and Laser Engineering Applications (ENSC 470), or an advanced optics from physics (for students making and designing more complicated optical systems.)
(5) Eng. Physics or Electronics background (for the micro-optics).
(6) ENSC 450 VLSI design important for the device design/simulation project are

NSERC Summer Project 2
Studying New Optical Chemical Sensors

This project is for students who want to gain experience in optical and chemical sensor methods to detect very sensitive levels of chemicals (eg Ammonia) with optical techniques. A common way of finding the presence of some gases or biological materials is to synthesize a specialized compound that changes its colour when exposed to the target agent. Think of the test strips you used in basic chemistry where the paper changed colour in the presence of acids. An expansion of this is materials that when hit by deep violet or ultraviolet laser light glow a specific color – this is called fluorescence. The figure bellows shows a material that we are working on that changes from a purple glow originally to a bright greenish one when exposed to Ammonia – an important chemical to detect for industry.



However, that full colour change only occurs at high concentrations of the gas and the smaller the gas concentration the less the colour change. If you want to measure very low concentrations (parts per million) of ammonia then you get an emission spectrum (light intensity versus wavelength) that is a mixture of both colours in these type of sensors. In a cooperative project between Chemistry and ENSC we have developed new methods of measuring the change in that spectrum with the exposure, which allows us to detect parts per million of ammonia. This metric can be generally applied to any fluorescence detection so we want to explore both applying this to a wide range of materials and increasing the accuracy in some regions.

Note we are setting these up so that in the event that COVID-19 is still restricting travel to SFU throughout the term this work can be done from your home until the labs are open. Depending on the student's background this project would range from:
(1) Taking our current experimental results (spectrums) obtained by a graduate student and exploring those to give us better accuracy. There are regions (ranges of gas density) where the sensitivity is modest with the current equations we use. However, we have found that we can improve sensitivity in those regions greatly by switching to a different analysis equation of the spectrum there. Students here would work with our team to develop need ways of looking at the spectrums in those regions to develop more sensitive equations.
(2) Our Chemistry coauthors are really good at creating new compounds that are tuned to emit different colours (wavelength spectrums) in the unexposed and exposed conditions. We are using our current measurements to create a general model of how to tune this change in colour to make it more sensitive. For example, is it more important to have the two colours far apart (ie one really violet and the other redder) or to have one emit its colour more strongly than the other, or combinations of both. If we can predict this we can tell the chemists how we want the materials to behave for maximum sensitivity. This would open some exciting new research.
(3) If Covid restrictions are reduced in the summer and we can get back into the labs then a student with the right background can move onto taking optical measurements of how the material's spectrum changes at different concentrations of gases. The apparatus has been developed by a graduate student so we be trying new measurement ranges of gases, and potentially new materials suggested by the analysis suggested in part 2.

Previous project students (both undergrad and graduate) have also been part of published conference papers on these results. In addition, this has generated an undergraduate thesis.

Skills Needed:
Student should be in third year or above. Some combinations of the following skills are needed, but not all of them:
(1) Good computer skills for PC based systems: spreadsheets & Matlab and/or C programming. Optics background is really needed for the part (3) option above
(2) Taken an introductory or advanced Optics courses from physics or engineering science (eg ENSC 470)
(3) Experience with adobe photoshop is useful though not required.
(4) Electronics, Eng Physics or biomed background is best
(5) Taken an introductory statistics course (eg. ENSC 280)

NSERC Summer Project 3
Creating a Low Computational Cost Magnetic Field Equation

With Prof. Glenn Chapman (ENSC)

This is project is for students with a Physics and Math interest, who like manipulating equations, and are good at programming. Back in second year you learned about how a magnetic field is created by current in a coil, and were shown the simple equations for the field along the axis of the coil. However most real engineering needs to calculate the magnetic field at points outside the axis. Those equations involve complex mathematical physics functions and are very computationally intensive. We are creating a series of approximations equations to the off axis magnetic field which have the potential to be both accurate and easy to compute. Each order of approximation is much more accurate than the previous with a modest increase in computational complexity. In this project the student would develop programs to create optimized approximations to minimize the deviation from the true values. If successful these equations would tremendously enhance calculations in many electrical areas, magnetic coil design, inductance calculations, and plotting magnetic fields effects. Students can participate in a journal publication on this topic (NSERC project students have generated 25 papers within my group). It certainly can be extended to a BSc thesis.

Depending on the student's background they will
(1) Developing parameter optimization programs to create the most accurate approximations over all space.
(2) Extending the approximations to higher orders for greater accurac and more complex coil designs.
(3) Developing new approximation solutions.

Skills Needed:
Student should be in third year or above. Some combination of the following skills are needed but not all areas are required. The skill set will determine the outline of project

(1) Taken a basic Electricity and Magnetism course like Physic 321 (advanced EMag courses are a plus but not required).
(2) Knowledgeable of Excel spreadsheets and programming them
(3) Good in C programming
(4) Experimented in Maple.
(5) Experienced in Matlab.
(6) Interested in solving tough mathematical problems to extend the approximations.