Initiating the Undergraduate Research Study through the NYC-LSAMP Summer Fellowship Program

Sunghoon Jang and Kenneth Markowitz

Department of Electrical and Telecommunications Engineering Technology
New York City College of Technology of CUNY
300 Jay Street
Brooklyn, NY-11201
sJang@citytech.cuny.edu

Abstract: Through the NYC-LSAMP summer fellowship program we have conducted a research project "Understanding and Studying of a Non-invasive Optical Glucose Sensing System Using the Advanced Opto-Electronic Technology" with a freshman student. There were some challenging points due to the student's level of engineering knowledge, we started to provide a series of mini-lectures in order to explain step by step the background knowledge in optics, electronics, physics, etc. in the beginning weeks. We also introduced and demonstrated basic opto-electronics equipments and devices including the oscilloscope, the laser, an optical chopper, a polarizer, a photo detector, a lock-in amplifier, etc. During the research project, we studied and investigated the fundamental knowledge and technology of opto-electronic devices with an understanding of their applications. In addition, we also investigated how a particular optical sensor works as a special application such as a glucose sensor for diabetics, and also attempted to design a glucose sensing system. In this study, we discussed the importance of undergraduate research and achievement of the preliminary study. The undergraduate research truly helped our student gain intellectual and practical knowledge of how engineering research is conducted and completed. Through the various research activities required by NYC-LSAMP Summer Research Program, the student also learned and improved his ability to achieve critical thinking, problem-solving & trouble-shooting skills, understanding engineering knowledge, increased confidence, enhanced career preparation, communication skills, etc.

Key words: Undergraduate Research, NYC-LSAMP Program, Opto-electronics, glucose sensor.

Motivation and Aim of Our Undergraduate Research

The motivation and aim of undergraduate research in developing of new and advanced knowledge or understanding are to provide or inspire students in order to respond and comprehend a diverse and fast changing technologies and knowledge in Electrical Engineering Technology education. We believe the research conducted by the undergraduate student is a very important learning process stressing design, practice, integration and application of the scientific and technical knowledge learned from the classroom through all kinds of activities related with their research.

Since our engineering research requires highly elaborate equipment and expensive materials with analytical and experimental knowledge and skills, this endeavor provided a very good opportunity to gain the depth of knowledge to students by planning, initiating, and conducting research in engineering principles. Due to theses process and factors unlikely other principles, it would make the undergraduate research in engineering make more complicated and difficult to initiate, conduct, and complete with undergraduate students. As a mentor of undergraduate research we believe that students should have a reasonable opportunity of completing his or her project within a given time producing useful and reasonable results. Hence we paid more attention to evaluate each student's level in terms of interest, knowledge, ability and capacity. Finally, students will learn theoretical and hands-on experimental methods of how to pursue engineering research applying independently with critical & creative thinking, problem-solving, and trouble-shooting skills.

The NYC-LSAMP Summer Fellowship Program

"The NYC Louis Stokes Alliance for Minority Participation (NYC-LSAMP) is an alliance of 16 CUNY Colleges and the CUNY Graduate Center. The Alliance goal is to substantially increase the number of underrepresented minority students who pursue and graduate with Baccalaureate Degrees in Science, Technology, Engineering and Mathematics (STEM). Since November 1992, the Alliance has been at the forefront of a concerted effort to increase annual Minority STEM enrollment and graduation in community of the City University of New York. The Alliance provides academic scholarship support to CUNY students majoring in the STEM disciplines, making research an integral part of STEM education in New York City."

"LSAMP supports research training opportunities and academic support services for students to encourage greater participation in Science, Technology, Engineering and Mathematics (STEM), and to boost academic excellence. For the faculty and students in the community colleges this support is made possible through various financial incentives, including competitive faculty grants."

The NYC-LSAMP Summer Fellowship Program is NYC Louise Stokes Alliance's research experience program for a period of 10 weeks during the summer. Students will receive a scholarship of $3,000.00 to enhance their educational skills, for the summer in six payments. The AMP research assistantship is a competitive awards based on their overall GPA, academic achievement, and the recommendation of their faculty mentor. The NYC-LSAMP Summer Fellowship Program requires students to attend all meetings, participate in the schedule of AMP activities, and regularly attend research seminars as indicated by their faculty mentor. Students are also required to submit a weekly progress and final report on their research through the program. The final poster presentation is essential at the end of the summer program.

The Procedures for Initiating Undergraduate Research

The procedures for initiating undergraduate research required a framework of four phases as listed in following.

Phase 1: Preparation of Blueprint for a Research Subject.
Phase 2: Applying for the CUNY LSAMP Summer Fellowship Program.
Phase 3: Conducting Undergraduate Research Project.
Phase 4: Participation, Presentation, and Publication of Scholarly and Research Work.

All detailed activities of the four phases in developing course modules are listed in Table 1.

Phase 1: Preparation of Blueprint for a Research Subject.
• List and identify the student's interest in possible research topics. • Check literature and other available information and resources. • Evaluate the student's level of interest, knowledge, ability and capacity. • Confirm the research subject and plan with a time table. • Write a proposal including mission statement, goals, objectives, and etc. • Check the availability of laboratory room, equipment, and materials.
Phase 2: Applying for the CUNY LSAMP Summer Fellowship Program.
• Obtain the information including rules, procedures, and guidelines. • Find the opportunity with its requirements. • Check its availability and eligibility of the program. • Submit applications and track the progress.
Phase 3: Conducting Undergraduate Research Project.
• Conduct orientations to students introducing the laboratory and to the project. • Provide students with a relevant background literature and information. • Give mini-lectures about theoretical knowledge and hands-on experimental skills. • Engage in daily based research in the design, building, troubleshooting, and analysis of data. • Hold weekly meetings to review progress and discuss problems. • Evaluate research activities and collect student's feedback.
Phase 4: Participation, Presentation, and Publication of Scholarly and Research Work.
• Search opportunities and collect information of professional conferences and journals. • Guide students how to prepare and present research. • Submit weekly progress report and a final report. • Conduct seminars for presentation of research work to colleagues. • Collect their evaluations and feedback.

Table 1. The list of detailed activities in four phases of NYC LSAMP Summer Fellowship Program.

Design and Build a Non-invasive Optical Glucose Sensing System

Since we decided to work on our research topic "Understanding Basic Principles Knowledge and Technology of Opto-Electronic Devices", we started to provide a series of mini-lectures in order to explain an extensive background in optics, electronics, physics, etc in the beginning weeks. We also introduced and demonstrated basic opto-electronics equipment and devices including an oscilloscope, a laser, an optical chopper, a polarizer, a photo detector, a lock-in amplifier, etc. We strongly believe that orienting a student to the research, and providing all research related knowdge of theoretical and experimental background information is extremely important part in completing his or her project and achieving its goals more effectively and independently.

Our group studied and attempted to design and develop a non-invasive optical glucose system as an application of opto-electronic technology, because a non-invasive method of monitoring blood glucose would present major advantages over current existing methods which are using invasive technologies. The proposed glucose sensing opto-electronic system in current study may be capable of monitoring very low glucose levels in the physiologic range with the accuracy and precision that would satisfy medical criteria, since this method is expected to be fast, reliable, safe, and simple. The cost of the proposed testing device would be significantly lower than for existing methods because only a monitor with optical sensor would be required, and the high monthly expense of testing strips would be avoided. In addition, the patient acceptance for this methodology is expected to be high due to its non-invasive nature, and its simple and safe in regard to the testing procedure.

The main components of the open loop optical glucose sensor using the optical rotation of glucose molecule are illustrated in Figure 1. A HeNe laser and 1^{st} polarizer are used to provide linearly polarized light. The light is then passed through an optical signal chopper driven at about 1.0 kHz, and detected by a photo diode detector after controlled its intensity by 2^{nd} polarizer. The lock-in amplifier provides an output signal which is a V_{DC} voltage proportional to the amplitude of the reference signal present in the detected signal from the photo diode detector. This V_{DC} output voltage is fully monitored and recorded by an oscilloscope. Therefore the lock-in amplifier provides the phase and frequency locked detection of the 1.0 kHz component, which itself was proportional to the net rotation between the two polarizers disposed at 90° to each other. The optical rotation due to the glucose cell was proportional to the concentration of the glucose and the path length of the cell and the entire system sensitivity can be controlled by changing the gain constant of the lock-in amplifier. The block diagram of actual open loop system is shown in Figure 2.

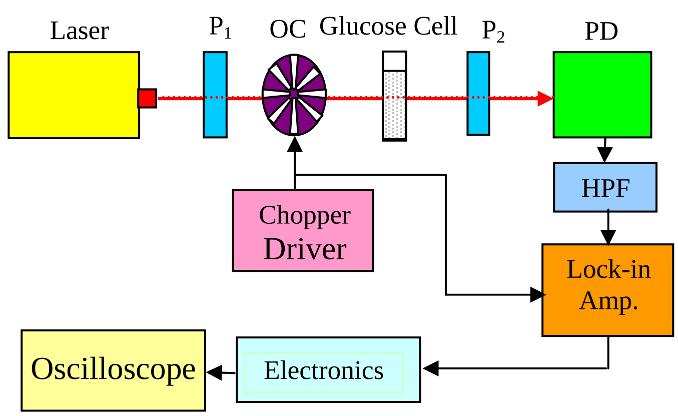

Figure 1: Block diagram of designed and implemented an open loop optical glucose sensing system: P_1 and P_2 are polarizers; OC is an optical signal chopper; Glucose cell contains various glucose solutions in physiologic range; PD is the photo diode detector.

The open loop system was first calibrated by measuring the V_{DC} outputs signal from the lock-in amplifier with applying various modulating frequencies in order to find the best fit for our optical glucose sensing system. The data shown in Figure 3(a) was obtained from the V_{DC} output of the lock-in amplifier by rotating the angle of the 2^{nd} polarizer at various system gains. Then the system sensitivity was measured of the V_{DC} output of the lock-in amplifier uses a fit of the data as shown in Figure 3(b). We found the system sensitivity of 6.4429 V/Degree, which means every 10 millidegree of rotation gives about 64.429 mV V_{DC} output. This sensitivity would be good enough to detect few millidegrees rotation of a glucose molecule.

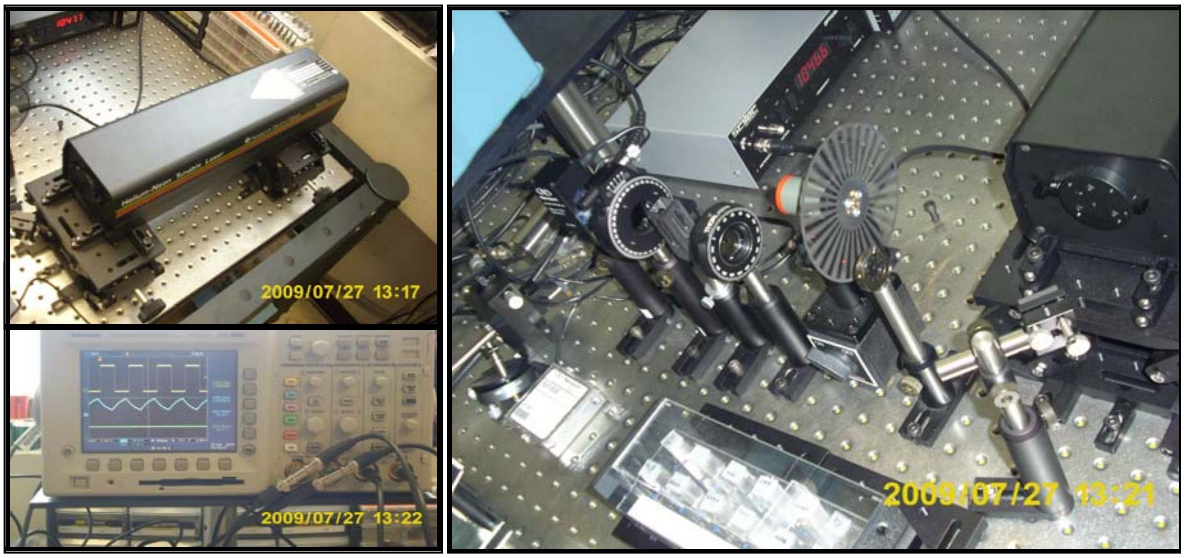

Figure 2: The actual open loop optical glucose sensing system using the advanced opto-electronic technology.

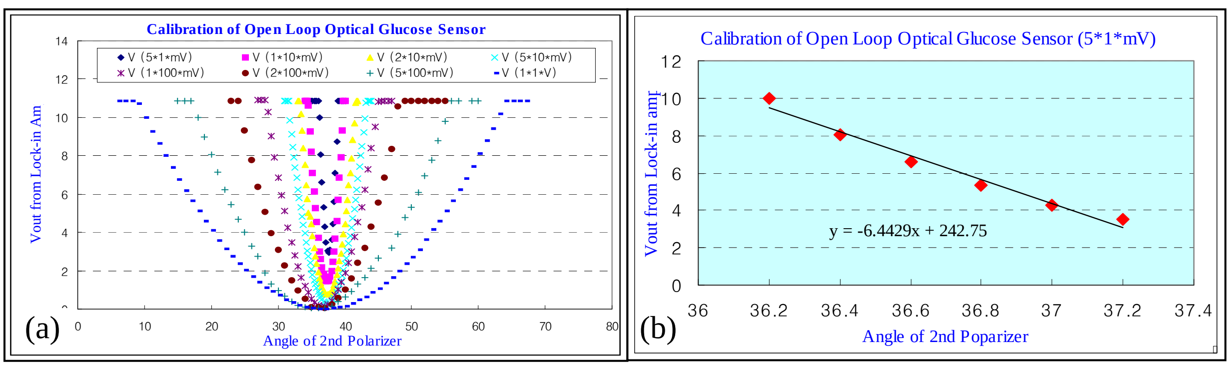

Figure 3: Calibrations of the open loop optical glucose sensing system (a) Plot of V_{DC} output from lock-in amplifier as a function of 2nd polarizer rotation in the open loop optical glucose sensing system illustrated in Figure 1 at various lock-in amp sensitivity. (b) Plot of V_{DC} output from lock-in amplifier at lock-in amp sensitivity (5×1×mV).

Results and Discussion

We have successfully studied and developed in introducing a non-invasive optical glucose sensing system using the advanced opto-electronic technology. The undergraduate research truly helped our student in gaining intellectual and practical knowledge of how engineering research is conducted and completed. Through the various research activities required by NYC-LSAMP Summer Research Program, the student also learned and improved his ability to think critically, problem-solve, trouble-shoot, and better understanding engineering principles. Our student presented the results of his research, "Studying and Developing a Non-invasive Optical Glucose Sensing System Using Advanced Opto-Electronic Technology," at the Annual Biomedical Research Conference for Minority Students (ABRCMS) in Phoenix, Arizona.

According to our student, "The experience was wonderful.” He received numerous research and internship opportunities from a number of companies and schools."

We would like to thank the NYC-LSAMP for supporting undergraduate research activities in financially and academically. We also want to express our gratitude to NSF Science and Technology Scholars program and the City Tech Foundation for supporting our student financially in travel and registration costs for attending and presenting his research work at the conference.

References

1. “Characteristics of Undergraduate Research,” Committee on Professional Training Newsletter, Spring 2002.
2. Wenzel T. “Definition of Undergraduate Research,” Department of Chemistry, Bates College.
3. Hunter A, Laursen S. “Becoming a Scientist: The Role of Undergraduate Research in Students’ Cognition, Personal, and Professional Development,” Wiley InterScience, October 2006.
4. Malachowski M. “The Mentoring Role in Undergraduate Research Projects,” Council on Undergraduate Research, December 1996.
5. Jang S., Markowitz K. “A New Approach to Present a Non-Invasive Optical Glucose Sensor Using Advanced Opto-Electronic Technology,” The ASEE Mid-Atlantic Section Fall 2009 conference.
6. NYC-LSAMP Website: http://nyc-amp.cuny.edu/NYCLSAMP/tabid/57/Default.aspx

Biography

Sunghoon Jang is currently an Assistant Professor in Electrical and Telecommunications Engineering Technology at New York City College of Technology of CUNY. He received the B.S. degree in Electrical Engineering from the Kyung-nam University, Korea, and his M.S.E.E degree in Electrical and Computer Engineering from New Jersey Institute of Technology, and his Ph.D. degree in Biomedical Engineering from University of Connecticut. Dr. Jang is a member of IEEE and BME. His technical areas include digital signal processing, opto-electronics, and control systems in Biomedical Engineering. He has published a number of papers in these areas. Professor Jang teaches in Electrical and Telecommunications Engineering Technology. Professor Jang may be reached at sjang@citytech.cuny.edu.

Kenneth Markowitz is currently an Associate Professor in Electrical and Telecommunications Engineering Technology at New York City College of Technology of CUNY. He received his B.S. degree in Electrical Engineering from City College of NY, and his M.S.E.E degree in Electrical Engineering from NY Polytechnic Institute of Brooklyn. He is a registered professional engineer in state of NY. His research has been focused on digital systems and control systems in variety fields of applications. Professor Markowitz teaches in Electrical Engineering Technology. Professor Markowitz may be reached at kmarkowitz@citytech.cuny.edu.