An NSF Grant with ITT Industries

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Abstract:

An NSF GOALI grant (Grant Opportunities for Academic Liaison with Industry) was approved for the period June 1997 through May 2000. The grant supports applied research in areas related to weather satellite instrumentation, a principal business of ITT (Aerospace-Communications), a division of ITT Industries located in Fort Wayne. This grant, with matching funding from ITT, paid summer salaries for two faculty members from the ECET department and two from the EE department to work full-time at ITT. The professors' ¼ time research release during the academic year was also devoted to the applied research and was supported by the University. The discussion below provides information on the grant process, the areas of applied research, and on how the research and the relationships with engineers and managers at ITT helped the ECET department.

I. Introduction

Indiana University Purdue University Fort Wayne (IPFW) is a state-supported commuter campus with about 12,000 students (about 5500 FTE). The School of Engineering, Technology, and Computer Science contains 5 departments: engineering, electrical and computer engineering technology, manufacturing technology, civil and architectural engineering technology, and computer science. ECET provides instruction for accredited[1] A.S. and B.S. programs in Electrical Engineering Technology (EET), with options in computer engineering technology. There are about 220 students majoring in EET and over 1100 students have received Purdue EET degrees during the past 35 years. The average age of our students is about 28 and most have full-time employment. The Engineering Department provides instruction for accredited[2] B.S. programs in Electrical and Mechanical Engineering. The number of EE majors is approximately equal to the number of EET majors.

ITT (Aerospace-Communications) builds weather satellite instruments for NOAA (National Oceanic and Atmospheric Administration), builds SINCGARS, frequency-hopping military radios and is one of the top ten employers in the area. Hundreds of engineers work at ITT and over 50 EET graduates and a number of current students work there, primarily as engineers and technicians. Generally, when an ITT employee receives a B.S. degree in EET, the person is promoted to an engineering position.

Four areas of research involving weather satellite instrumentation were selected for study: Adaptive control to improve imaging (visible spectrum) and sounding (IR

spectrum); Digital post-processing of interferometer spectra; a new method of estimation of position of the moving mirror in an interferometer; and Microbolometer arrays. All of these are areas of applied research since ITT uses them while designing and constructing weather satellite instruments. The instruments that provide many of the cloud photos of the United States for TV weather broadcasts were built in Fort Wayne.

Professor Broberg, the principle investigator, and Professor Lin will each complete 2 ½ years of applied research while Professors Alam and Oloomi, EE department, will each complete 1 year by May 2000. The work will result in 4 - 6 technical papers and a possible patent. Also important were the relationships developed with people at ITT and the effect of the relationships on the faculty, students, and alumni. While maintaining second offices (cubicles) at ITT was difficult, the applied research was interesting and examples from the applied research were used in courses from basic circuit analysis thru advanced control and digital signal processing.

II. The Grant Application

In the Fall of 1995, the NSF GOALI program looked interesting and Professor Broberg decided to apply for funding to continue the work he was doing with ITT since his PhD dissertation[3, 4]. In order to make this proposal stand out and give it a better chance of acceptance, the following goals were set:

1. Obtain matching funds from ITT (Aerospace/Communications) for faculty work during the summer.
2. Obtain a commitment from the University and the faculty involved to provide one academic year of ¼ time research release for each summer of full-time work at ITT. This commitment translated into matching funds from the University in the grant budget.
3. Request that ITT select areas of applied research with direct application to the weather satellite instruments built in Fort Wayne.
4. Involve faculty from Electrical Engineering to show collaboration between departments.
5. Find the best faculty members for the areas of applied research chosen by ITT
6. Rewrite and proofread the application until it was flawless.
7. Submit the application in a timely manner.

To meet these goals, cooperation and assistance from ITT managers was required. In late 1995, one ITT manager took the initiative and determined the most promising areas of research by requesting input from many of the engineers and scientists working on satellite instrumentation. He also obtained a commitment from ITT to provide matching funds for the on-site applied research at the ITT facility by IPFW faculty. Later, after the NSF grant was approved, another ITT manager, handled the funding, scheduling, office space, computers, software, etc required for 4 faculty members to work on-site at ITT. This cooperation and assistance was vital to the grant request and to fulfilling the requirements of the grant. Finding industrial managers willing to spend the time required to initiate this type of project may be the most difficult part of obtaining a similar grant.

Next, it was necessary to match these areas of research to the most capable engineers in both ECET and EE and to get faculty commitment to devote research time to the project. The education, accomplishments, and activities of the faculty were important to ensure that each faculty member involved had prior knowledge in the area of research in which they would work. A brief summary of how faculty and their areas of expertise matched the applied research topics is shown below:

1. Adaptive control to improve imaging (visible spectrum) and sounding (IR spectrum): This included repetitive and learning control (Prof. Broberg's primary areas) and h-infinity control (Prof. Oloomi's primary area).
2. Digital post-processing of interferometer spectra: This was primarily Digital Signal Processing and fit well with Prof. Lin's dual degrees in EE and CS.
3. A new method of estimation of position of the moving mirror in an interferometer: This involved considerable work in the area of optics, which is Prof. Alam's area of expertise.
4. Microbolometer arrays: This was a new area for any faculty member but involved resistor equivalent arrays and it became Prof. Oloomi's area.

Most of the simulation work involved Matlab/Simulink[5], however, MathCad[6], and other programs used at ITT were also available.

All of the areas chosen for research were related to use of the basic Michelson interferometer, shown in Figure 1, in a weather satellite.

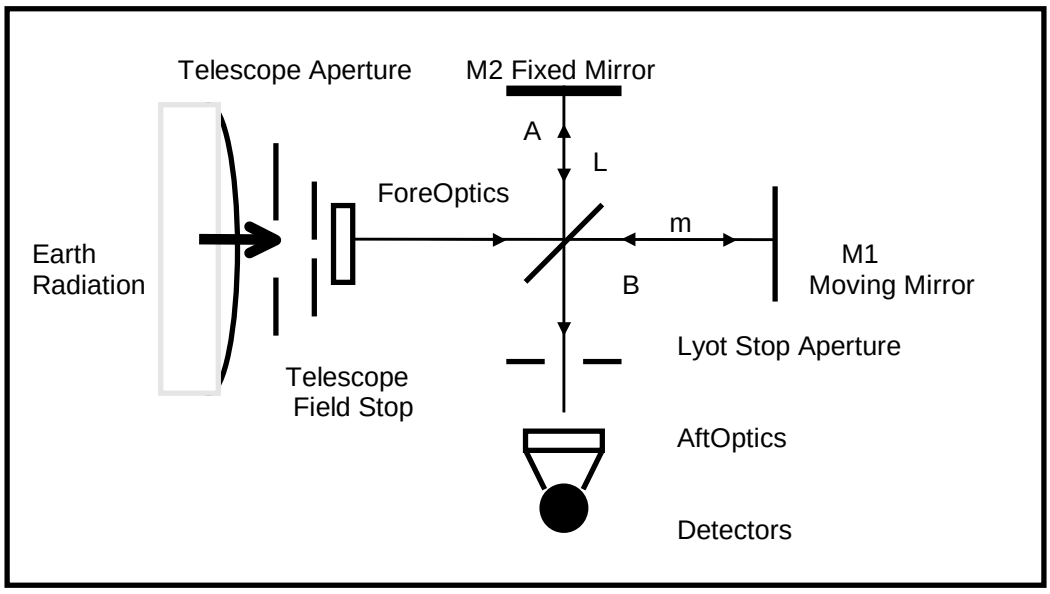

Figure 1. A Two-beam Michelson Interferometer

To put this mechanism into space (with a long, unattended lifetime) requires an extremely accurate linear servo to position the moving mirror, special signal processing techniques to determine the precise mirror position, and new DSP methods for processing the signals received by the optics.

III. Benefits of an Industrial Relationship to ECET

Having two ECET faculty work closely with ITT engineers and managers for three years has produced many of the benefits expected of close industrial relationships. We spoke frequently with current students and alumni who worked at ITT and they appreciated that we worked there and understood the work pressures they were under on a day-to-day basis. Current students frequently asked us about courses to take and other academic advice and alumni took additional courses in ECET to keep up with their fields (e.g. C++, Programmable Logic Controllers, Networking). One of our alumni received his M.B.A. and is a manager and another is close to completion of his M.S. in Engineering. A number of our graduates are also software engineers and program in C, assembly language, etc. Keeping up with the work and home activities of many of our alumni who work at ITT was rewarding and interesting.

Several alumni, who were experts in their fields and were engineers at ITT, are now some of our best associate faculty (part-time). One of the PhD, research engineers at ITT is also a valuable associate faculty member in ECET because of the relationship developed during our work there. It is quite difficult to find quality, part-time professors from industry because of the relatively low pay and the amount of preparation time involved. Industrial relationships are critical to finding these qualified engineers who are so necessary to most urban campuses. The work also resulted in the hiring of several EET graduates as engineers upon receiving their B.S. degrees, and a better understanding, by ITT managers, scientists, and research engineers, of the capabilities of our graduates.

Some of the work at ITT was proprietary, but none was classified and it was not difficult to find schematic layouts and other examples of the practical engineering work based on satellite instrumentation for use in the classroom. For instance:

1. Satellite circuit schematics were used to illustrate industrial practice and the need for basic circuit analysis.
2. Examples of transistor, diode, and operational amplifier circuits were used.
3. Intel™ microcontroller assembly language code was used.
4. Digital signal processor methods could be explained using practical examples. Figure 2 shows an example of basic DSP methods used by Professor Lin during the project.
5. Active filters are used in the satellites and were useful in classes.
6. Counting the optical fringes using a laser interferometer to determine the exact position of a linear motor as a part of a feedback loop provided an example that was quite interesting to students.
7. Use of a digital phase-locked loop in a closed-loop control circuit provided an example of a communications circuit used in motor control.
8. Matlab and Simulink are used in several upper level courses for analog and digital signal processing analysis.
9. Basic control methods, such as those shown in Table 1 (similar to one developed by Professor Broberg during the initial stage of the project) were used to explain general control techniques.

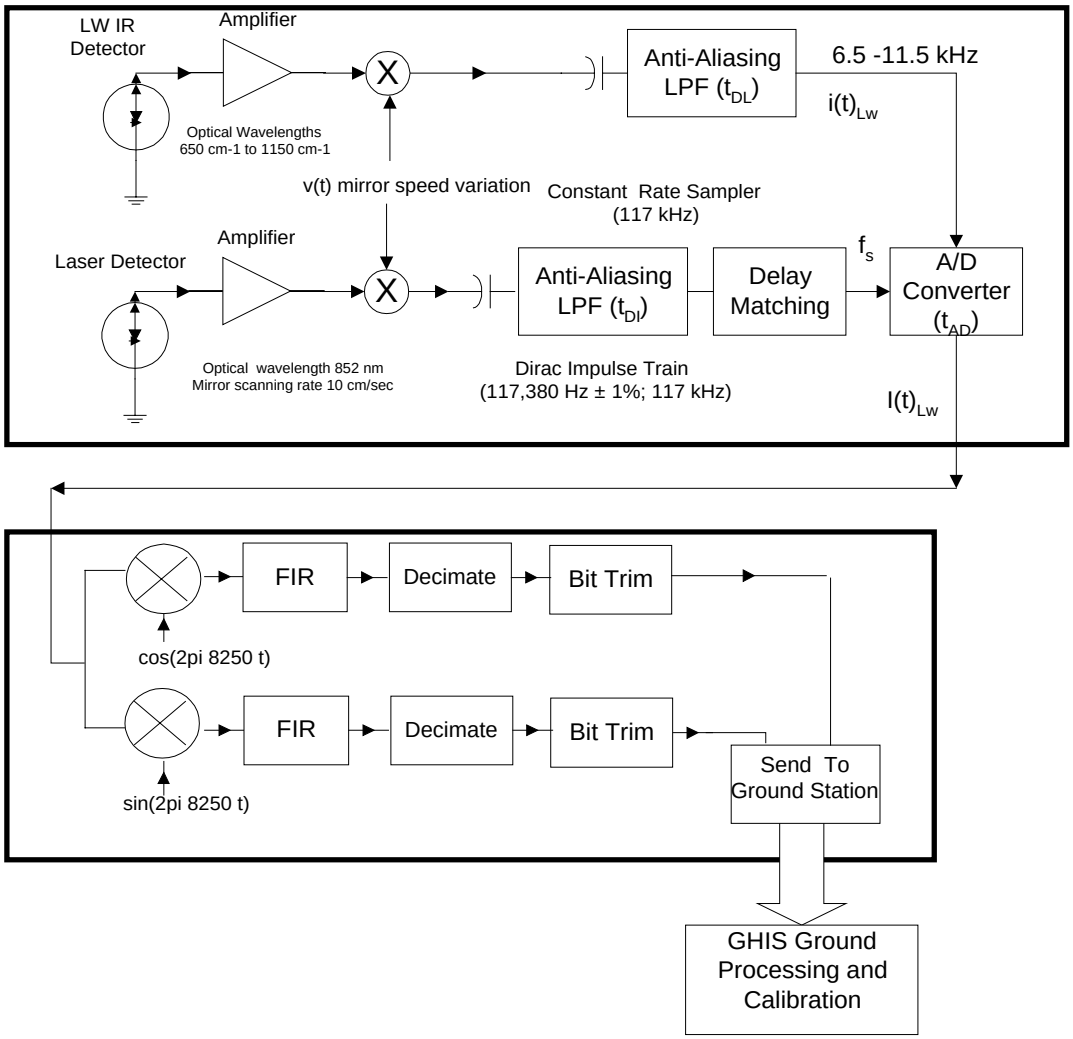

Figure 2: Top Level Block Diagram of Conventional Signal Processing Approach

Faculty knowledge of current engineering workgroup practices is important to help prepare students to enter the workplace as technicians and engineers. The total dependence of most industries on contracts and the resultant possible layoffs and reorganizations that result when contracts are not won is also valuable knowledge when advising students on career options. Experiencing the inner turmoil during company layoffs, buyouts, mergers, or divestitures is also an experience that can be valuable when advising or just chatting with students. Recent faculty work in industry is vital to maintaining a knowledgeable faculty and a viable program in engineering technology. Faculty members need to keep up technically, but also need to understand what students experience when they go to work in order to advise and help them.

The major benefit of a long-term industrial relationship and a quality program is to the students and graduates. Out of 54 EET graduates listed in the current alumni directory as

being employed at ITT, 33 have engineering titles, 16 have technician titles, 4 are managers and 1 has no title listed. This is only one of the many companies, both large and small, where over 1100 graduates of this program work and the graduates have been accepted as technicians (generally with an A.S.) and engineers (generally with a B.S.) in most areas of industrial electricity and electronics.

	(Tracking Accuracy	Commonality with other Applications	Realizable with Space-Qualified HW	Software Complexity	Comments
Proportional	Poor	Yes	Yes	Low	Offset.
PI	Fair	Yes	Yes	Low	Current Michelson uses a digital PI algorithm
PID	Fair	Yes	Yes	Low	Proven classical method
Lead	Fair	Yes	Yes	Low	Currently used
Lag	Fair	Yes	Yes	Low	
Lead-Lag	Fair	Yes	Yes	Low	
Self-Tuning	Good	Possible	Possible	Medium to High	Self-tuning PID algorithms are a mature technology.
Feedforward	Good	Possible	Possible	Medium to High	Requires good plant model
Feedback Model-Based	Good	Possible	Possible	Medium to High	Includes MRAC. Depends on plant model
Feedback Rule Based	Good	Possible but not likely	Possible	Medium to High	Includes fuzzy logic and knowledge based
Repetitive	Good	Yes, for periodic scans	Yes	Low to Medium	Used in a current instrument.
Adaptive-Repetitive	Good	Yes, for periodic scans	Possible	High	Good for widely varying plants or disturbances

Table 1: Classical and Adaptive Feedback Techniques

IV. Summary

The keys to having the best chance of obtaining an NSF grant of this type are: obtain a commitment for matching funds from your industrial partner, obtain a commitment from the university, obtain a commitment from the faculty involved, have your industrial partner select the areas of applied research, have faculty from more than one department involved to show collaboration, select the best faculty members for each area of applied research, present a flawless proposal and submit it in a timely manner.

Almost all of the work on the grant is completed and the required report to NSF will be prepared in a few months. It has been an interesting and worthwhile experience and, I believe that any energetic faculty member, with industrial contacts can obtain a similar grant with sufficient preparation and effort.

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5. The MathWorks, Inc. 24 Prime Park Way, Natick, MA 01760
6. MathSoft Inc, 101 Main Street, Cambridge, MA 02142-1521

HAL BROBERG
Hal taught Electrical Engineering for 3 years at the U.S. Naval Academy and after retirement from the Marine Corps as a Lieutenant Colonel, chose to continue teaching. He received his PE license in Indiana in 1988 and his PhD in Engineering (EE) in 1993. His research area is servo systems and he has consulted and worked for ITT (Aerospace-Communications) on weather satellite servos for the past 8 years. He is currently an Associate Professor in the ECET department at Indiana Purdue University in Fort Wayne, IN, a senior member of IEEE and a program evaluator for IEEE with ten TAC/ABET accreditation visits completed.

PAUL I-HAI LIN
Paul is Associate Professor and Chair of the ECET Department of Indiana Purdue University Fort Wayne. He has been with Purdue University since 1985 and is a registered Professional Engineer (EE) in California and Indiana. Prior to joining IPFW, he taught in the Engineering and Technology Department of Dutchess Community College (NY) for three years, in the Electrical Engineering Department of National Taipei Institute of Technology for two years, and worked in industry for 8 years. Lin is a Senior member of IEEE and was the Chairman of the Manufacturing Systems Development and Application Department of IEEE-Industry Applications Society from January 1998 to December 1999. Lin's current interests include distributed intelligent control of embedded real-time systems, and sensors in industrial control applications.