The Importance of Lecture and Lab Configured Courses To Enhance Interests in Engineering Education

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Abstract

Properly educating students within various engineering disciplines is a very important task for all parties involved in the process. It is essential that prospective engineers are given a sufficient amount of theory and lab experience to facilitate the influx demand of their skills in the 21st Century industry settings, independent engineering practices, etc. Most engineering students sustain the capacity to grasp complex engineering concepts however; this theory-based knowledge is far from sufficient. Practicing engineers have responsibilities of innovation that are bestowed upon them to impact society positively. This social responsibility is also present within engineering students. This paper will discuss the adequate balance of theoretical applications in conjunction with laboratory experiences needed to properly prepare the student to become technically versatile students. The theory and laboratory experience needed will be related to an undergraduate control system course. This type of course is utilized because of the affiliation it maintains within engineering disciplines such as electrical, mechanical, civil and chemical engineering. These disciplines of engineering directly and/or indirectly relate to each other and can positively or negatively influence engineering solutions. Therefore, at least partial knowledge of fundamental concepts regarding most engineering disciplines should be attained to make more thorough analysis procedures and design solutions. This knowledge will serve as background information to decrease the chances of developing poorly designed engineering solutions. This paper will also serve as a tool to encourage all engineering students and their affiliates (engineering professors and mentors) to become thoroughly engrossed in the learning process within the field of engineering.

Introduction

Engineering is a discipline that has the capacity to span into many areas that are not directly engineering affiliated. Engineers perform work for many companies that are not engineering related, but utilize machinery and equipment that is based on basic engineering concepts. These concepts are universal to all technically sound engineers. The aspect that contributes to a well rounded engineer but is detrimental to a one dimensional engineer, (merely proficient in understanding the theory behind engineering concepts) is his or her ability to apply actual life situations to the problem. Observing the workspace that the engineering machinery will be incorporated into and knowing exactly what type of performance the company needs out of this equipment helps engineers with their solution process. The ability to analyze facts, make needed assumptions, and infer sound decisions, are skills that should be developed over a large span of time to ensure that many different circumstances in different arenas have been experienced by the engineer.

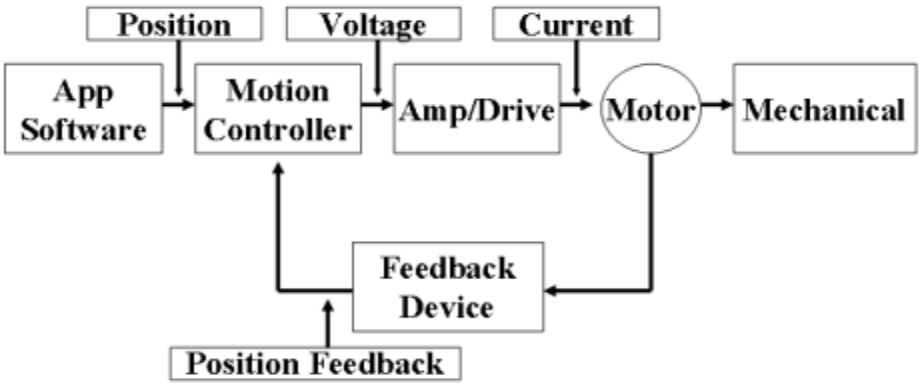
Today's Lecture and Lab Courses

On most college campuses, freshman engineering students begin their engineering experience within their second semester of being in their prospective major. The outside courses that they enroll in (i.e., mathematics, physics, etc.) are geared toward building a solid foundation that engineering will be able to be built upon. Basic engineering courses (i.e., Introduction to Engineering, Engineering Programming and Communications, etc.) do not focus on a particular discipline of engineering. Rather they are broad courses that all engineering students must take. This is done to familiarize each student with the necessary knowledge that will be required of them in more specific engineering concentrated courses. Outside courses as well as the basic engineering courses prepare the incoming freshmen for experiences they will soon be faced with. It also gives them a chance to make the decision if they truly want to matriculate in the field of engineering or move on to a more suitable field. The lectures and labs that today's students are enrolled in can be very beneficial to their education. Conversely, the two part course can seem to be a waste of time to the student if the material in one of the courses or both is not understood. If the latter decision is made, it can be either partially or fully contributed to the student's and/or the professor's amount of involvement in every aspect of the courses. At the undergraduate university level, professors are not required to be an essential structure in the overall learning process of the student. It is the students' responsibility to achieve independent learning outside of class in addition to the information that is discussed in lectures. Even though it is possible that concern and attention from the professor can be directly related to understanding concepts, it is not a requisite. Learning is contingent on the students' desire and motivation to absorb the information at hand. The complementary part of the lecture, which is the lab, applies the theoretic knowledge to a hardware/software (test equipment, simulation programs, etc.) structured environment. Each facet of engineering embodies certain lab environment characteristics that reflect industry type apparatus and testing equipment. The overall success of a

practicing field engineer, more times than not, is a reflection of the efforts he or she demonstrated in preparatory undergraduate labs.

A Control System Approach to Engineering Education

Within the field of engineering, certain topics overlap specific engineering disciplines. The concept of a control system course is affiliated with many braches of engineering. Some of these branches are civil, electrical, mechanical, and chemical. Conceptually, a control system is a component or system of components functioning as a unit, including control valves and sensing, warning, relief, shutdown, and other control devices, which is activated either manually or automatically to establish or maintain the performance of another component. This means that it is a system that controls the functionality of another system or series of systems with regard to requirements that must be maintained. Control system courses are established in many engineering curriculums and the idea of a controls course incorporated within the curriculum of every engineering discipline is an idea worth devoting serious attention to due to the frequent basis that control system applications are involved in engineering processes. It is also due to the direct correlation between control technology and its commonplace application in industry settings. Many times control system applications are required within industry settings to facilitate safety concerns of many processes. Many of these processes could be hazardous if not properly regulated. Therefore, the importance placed on both industry and university preparatory education of control technology is extremely relevant especially in a laboratory type environment. A motion control system algorithm is illustrated below:

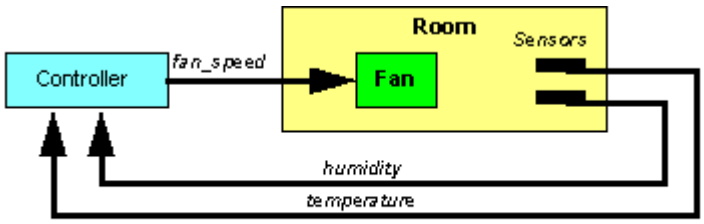


If a safety component was to be incorporated within the algorithm, it would rely on the feedback device to be a consistent performer. The feedback device sends positive and negative data to the controller to make appropriate decisions on how to react to given data. Control systems that govern dangerous industry type applications need safety components due to the nature of their existence. Without safety components (i.e., emergency shutoff switches) employees that work around the dangerous industry applications could be in serious danger. Specifically, the control system algorithm embodies electrical and mechanical engineering concepts. Therefore, those engineers

affiliated with the system need to know how and why each system component functions in the manner in which it does and what to do when errors occur. Within the illustrated motion system algorithm, application software is incorporated into the design. Engineers gain early experience with software packages and programming languages as early as the freshman level. A freshman level *Engineering Programming and Communications* course introduces students to various software packages and programming languages. Most basic control systems incorporate application software, input and output signals, controllers, and feedback devices. These components incorporate a vast amount of technology from many engineering disciplines. In many university engineering departments, (i.e., civil, electrical, and mechanical) each discipline's curriculum incorporates at least one course from the remaining disciplines. This enables the students in each discipline to have experience in more than one engineering field. In turn, this wide array of engineering education is extremely valuable to every venture in the student's post undergraduate career.

Controller Functionality

The controller component in the control system can be one of the most complex components for engineering students to fully comprehend. Its purpose is not difficult to comprehend, but the technical reasoning behind why it reacts in the manner in which it does can be somewhat difficult. Types of controllers are well varied. Determinations as to which type of controller to utilize within a given system depends upon the function that the system will provide. For instance, some controllers are better suited to work in certain systems due to the functionality that they provide for that particular system. A fuzzy logic controller would be incorporated into a design if vague or approximate values were given and from this information, definite conclusions were made. A sample control system utilizing fuzzy logic control is illustrated below:



The conditional statements below illustrate the wide range of solutions affiliated with this circuit utilizing the fuzzy logic controller:

IF temperature IS cold AND humidity IS high THEN the fan speed IS high.
IF temperature IS cool AND humidity IS high THEN the fan speed IS medium.
IF temperature IS warm AND humidity IS high THEN the fan speed IS low.
IF temperature IS hot AND humidity IS high THEN the fan speed IS zero.

IF temperature IS cold AND humidity IS med THEN the fan speed IS medium.
IF temperature IS cool AND humidity IS med THEN the fan speed IS low.
IF temperature IS warm AND humidity IS med THEN the fan speed IS zero.
IF temperature IS hot AND humidity IS med THEN the fan IS zero.
IF temperature IS cold AND humidity IS low THEN the fan speed IS medium.
IF temperature IS cool AND humidity IS low THEN the fan speed IS low.
IF temperature IS warm AND humidity IS low THEN the fan speed IS zero.
IF temperature IS hot AND humidity IS low THEN the fan speed IS zero.

These conditional statements make the fuzzy controller very thorough in its vast number of possible scenarios which is a main contributor as to why fuzzy logic controllers are extremely widespread today. Problems with fuzzy logic controllers arise when students are confronted with equations to understand how to tune the fuzzy controllers. Tuning the fuzzy controllers require that certain knowledge about the controllers is known. For instance, the equation,

$$J = \int_0^{Ts} \tau(\Delta\omega(\tau) + \Delta P_m)^2 \, d\tau$$

represents the optimal gain present in relation to tuning the fuzzy controllers. The logic behind the equation can be better understood with relation to a lab type experience. The lab type experience can allow for troubleshooting, analysis of results, and well designed solutions. The complementary fashion by which the lecture and lab enhance each other's validity to the students' understanding of the presented engineering topics is undeniable and is of utmost importance. Specifically, the use of controllers in a lecture/lab type scenario is beneficial to the student due to the many ways that the controller can be utilized within an industry setting. For example, the controllers can be utilized in many applications outside of the specific field of expertise that the student chose to specialize in. In these situations, being well educated in the functionality of the controllers is extremely important. Engineers must possess the ability to adapt to given situations and use attained education, incorporate creativity, and develop a strategy to make the situation function with the greatest amount of balance between cost, safety, and functional efficiency. Controllers are an advantageous means to troubleshooting engineering scenarios due to their widespread incorporation within various industry settings. The incorporation of fuzzy controllers into engineering settings makes the lab/lecture experience invaluable and hence, must be taken into consideration.

Conclusion

Through out the gamut of engineering researchers, engineers in industry, independent consultant engineers, etc., each of the different applications in which the various engineers are involved leads to the foundation from whence they came. The foundation of a solid engineer begins with the thorough understanding of the requirements that the discipline encompasses. Many engineers are different in the approach that each takes in

the pursuit of designing solutions. However, if the engineer has been well trained with respect to undergraduate lectures and labs, he or she has an advantage over the engineer with a lack of thorough engineering training. Undergraduate training allows the student to understand how most engineering disciplines have some overlapping into other engineering areas. The overlapping of engineering disciplines is a law of nature and not purposely done by man. It should be noted that each engineering discipline in some way plays a part on the other disciplines ability to be effective in various settings. The reliance that each engineering discipline shares with each other is also illustrated by the lectures' reliance on the labs and vice versa for the two to be as beneficial as they can to the engineering students' learning process.

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