A Desirable Undergraduate Program in Biomedical Engineering

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Abstract

A desirable curriculum is proposed for undergraduate programs in biomedical engineering. The programme emphasizes Electronics, Computing, Instrumentation, Signal and Image Processing, and hopes to produce graduates who can face the medical electronics industry, post graduate and research institutions with confidence. Adequate background in mathematics is ensured. By restricting the eligibility to students who have studied biology in their plus two program, we can obviate the need for teaching detailed courses on anatomy and physiology. Courses such as artificial organs are best avoided, being subjects highly interdisciplinary in nature and hence, offered at an UG level, become purely descriptive in nature. I do not, however, say that awareness of these areas is unnecessary. Adequate exposure to such topics can be provided by arranging invited lectures by doctors and researchers working in related areas. In addition, each student can be given one topic and asked to present it as a seminar to the rest of the class. The sixth and seventh semesters will have one elective each, from a choice of three sets, namely, (i) pattern recognition, followed by computer graphics, (ii) PC based medical instrumentation, followed by DSP System Design (iii) medical signal processing, followed by DSP System Design. The final project of the student is preferably taken in the same line as his set of electives.

Index Terms--education, undergraduate, curriculum, electives, medical electronics, biomedical engineering.

I Introduction

Recently, a number of colleges have started undergraduate programs in Biomedical Engineering (BME). Currently, the job opportunities for these graduates are dismally bad. Industries manufacturing medical equipment prefer to employ electronics rather than BME graduates. Not without reason. Most programs teach some instrumentation [2-5], some physiology and anatomy [2,3], biomechanics [2], biochemistry [2], biomaterials, clinical sciences [2], a course in artificial organs [4], biomedical transport phenomena [5], etc. - widely different courses without giving adequate expertise to the students in any one aspect. Further, government hospitals are yet to wake up to the idea of employing biomedical engineers. Even in private hospitals, they end up liaising with the service personnel from the industries supplying the various equipment. The salaries and the growth prospects of biomedical engineers in hospitals are also not attractive as compared to employment in industries. It is the opinion of the author that any technical specialization must only be at the post-graduation level and the purpose of any good undergraduate program is primarily to give good founding in anyone mother discipline of engineering. In the section below, the author gives several reasons in support of his opinion as expressed above.

II Case against the UG (BME) program

Looking from the industry viewpoint, entertainment electronics is a major part of today's electronics enterprise. But, we have not started any B. E. in Entertainment Electronics. One needs to keep in mind that this also requires certain additional knowledge in terms of human stereo listening capability, vision physiology (sensitivity to color, number of gray levels, logarithmic response to increasing intensity), etc., which are very much used, for example, in the perception based coding of audio and video data. Manufacturing of computer peripherals is probably another major industry, involving products as wide as floppy drives, dot matrix printers, CD ROM drives, plotters, magnetic cartridge drives, monitors, inkjet printers, optical scanners, laser printers, modems, network cards, and so on. One need not think twice to accept the fact that a lot of specialized knowledge is needed in the production of many of these

products. Does it mean that we need to start a UG programme in PC peripheral electronics? Similarly, we have other specialized applications such as avionics and military electronic products. No attempt has been made to start undergraduate programs in these disciplines. Then, what is special about BME? Based on preliminary survey [1], biomedical graduates as well as the industry strongly feels that electronics graduates can very well satisfy the requirements of the industry and can easily acquire the additional peripheral knowledge required of the associated anatomy and/or physiology.

This is not to say that the field itself is of less importance. The very fact that we are having a conference of this type shows the importance and relevance of the field. A careful look at the cross-section of people attending this conference shows that research in this budding field can be fruitfully done only by the hearty co-operation of experts in various fields, such as mechanical, metallurgy (material science), toxicology, VLSI specialists, etc., etc. To expect the maturity and capability of such a variety of people to be imparted even at a minimal level is a day dream at the UG level. Then, what are the alternatives to promote our field? The following are some suggestions by the author, and, by no means, it is a complete list. Organisations such as the Biomedical Engineering Society of India must take a lead role in these and other such endeavours.

A. Suggestions to promote BME :

- Promote biomedical electives in every branch, electrical, electronics, computer science (medical informatics), mechanical (biomechanics, biofluid dynamics), chemical (toxicology), metallurgy (biomaterials), etc.
- Announce awards for good biomedical projects, irrespective of parent branch of the student, or, if possible, one in each of the branches.
- Facilitate guest lectures from Industries and biomedical researchers in all Engineering colleges, by creating a list of Distinguished Speakers in different specialty areas.

Having said all this, the author takes a deeper look at the existing curricula in the BME programs, with a view to suggest improvements, with his limited knowledge. One is yet to see even one good book in medical instrumentation, which really gives design details of the internal circuitry. Of course, nobody can deny that it is not an easy task to write such a book. The point is that, in the absence of such texts, students are rightly feeling that they know very little of what is inside any medical equipment. So, the author feels that there must be less emphasis on such courses, which can only be taught with a block diagram approach, without real insight into the instruments. Naturally, we must strengthen the knowledge of the students in the basic analog and digital hardware, and also software.

Most of the currently existing undergraduate programs in biomedical engineering (BME) are offered by Electrical, Electronics or Instrumentation Engineering departments. Keeping this in mind, and constrained by my knowledge, and maintaining my view that I do not want this branch to proliferate at the UG level, I restrict my suggestions to a program concentrating on Electrical Engineering background to the students. Obviously, this does not mean that we downplay the role of biomechanics/rehabilitation, cellular engineering, or biomaterials in medicine. Further, as things stand, there are not many jobs in India in these areas, and even when they exist, their interests will be better served by graduates of the respective major disciplines of engineering, with an aptitude towards, and an awareness of the special needs of, medical systems.

In view of the suggested focus on only Electronics and related subjects, I suggest renaming the programme as Medical Electronics, since there is neither emphasis on general BME, nor anything "bio(logical)" in the curriculum. The section below proposes a new curriculum for a B.E. program in Medical Electronics (ME) that emphasizes Electronics, Computing, Instrumentation, Signal and Image Processing, topics of prime interest in existing and emerging areas of medical electronics. It aims to produce graduates who can face the medical electronics industry, post graduate and research institutions with confidence. Adequate background in mathematics is ensured. The author feels that anatomy is irrelevant for engineers, while physiology and medical physics are pertinent. It is suggested to restrict the admission to students who have studied biology in their plus two program. Highly interdisciplinary courses, such as artificial organs, are avoided, since they become purely descriptive in nature when offered at the UG level. Satisfactory exposure to these and other topics such as biomechanics and biomaterials can be provided through invited lectures by doctors, engineers and researchers working in related areas and by promoting student seminars on a regular basis. The 6th and 7th semesters have an elective each,

to be chosen from (i) pattern recognition, followed by computer graphics, (ii) PC based medical instrumentation, followed by DSP System Design (iii) medical signal processing, followed by DSP System Design. The electives could be chosen based on the topic of final project, so that he/she builds up expertise in (i) medical imaging and image processing, ***or*** (ii) Microprocessor, PC and Digital Signal Processor based instrumentation, ***or*** (iii) medical signal processing.

III Suggested Curriculum for B. E. (ME)

I year subjects :

English
Maths I
Physics I
Principles of Electrical Engineering I
Engineering Mechanics
Physics Lab
Workshop Practice

Maths II
Physics II
Principles of Electrical Engineering II
Principles of Mechanical Engineering.
Engineering Graphics
Computer Programming in C/C++
Computer Aided Graphics Lab (using AutoCAD)
Computer Programming Lab in C/C++

II year subjects :

Human physiology
Mathematics III
Devices & Analog Electronics
Data Structures and Algorithms
DC and AC Motors
Transducers & Instrumentation
Analog Electronics Lab
Electrical Machines Lab

Mathematics IV
Medical Physics
Linear Integrated Circuits
Pulse and Digital Circuits
Electronic Circuits
Signals & Systems
PCB Lab
Linear IC Lab

III Year

Analytical Instrumentation
Linear Control Theory
Digital Electronics
Power Electronics
Computer Organisation
Data Acquisition Systems
Digital Electronics Lab
Graphics Programming Lab (C/Visual C++)

Medical Instrumentation
Microprocessors
Communication systems
Digital Signal Processing
Elective: Pattern Recognition **or** PC based Instrumentation **or** Medical Signal Processing
Microprocessor Interfacing Lab
Digital Signal Processing Lab

IV Year

Technical Reporting (Oral & Written exercises)
Microprocessor based design
Hospital Management
Medical Imaging
Digital Image Processing
Elective : Computer Graphics **or** DSP System Design
Medical Instrumentation Lab
BSP Lab (with MATLAB)/ Image Processing Lab

Project Work (dedicate the entire 6 months of the eighth semester to the project, in order to give adequate exposure to the student to practical problems and get experience in applying the knowledge gained earlier.)

Acknowledgment

The author remembers with gratitude his friend, philosopher and guide, Prof. T. M. Srinivasan, who initiated him into the field of biomedical engineering and showed him the way to proceed with clarity in this highly interdisciplinary field.

References

1. Lakshmeesha and A. G. Ramakrishnan, “Biomedical Engineering Education and Job Prospects in India,” in *Proc. National Conf. BME*, Manipal, 1998, April 9-11.

2. Regulations, Scheme of Examination and Syllabus for B.E. in BME, Mangalore University.
3. Scheme of study and Examination for B.E. in Medical Electronics, Bangalore University.
4. Syllabus for M.Tech. Degree in Biomedical Instrumentation, Mysore University.
5. B. Tech. BME Curriculum – An Overview, Govt. Model Engineering College, Kochi.

Appendix

Is biomechanics unnecessary?

There are very few jobs for biomechanics specialists. The current UG (BME) are ill-equipped to handle any prosthetics/orthotics. Mechanical engineers with an interest in this direction can really perform much better.

Is biomaterials unessential?

Currently, there are very few jobs for biomaterials specialists. The current UG (BME) are ill-equipped to handle any serious work related to biomaterials. Metallurgical engineers with an aptitude in this direction, with the help of toxicologists, can contribute positively in this area.

Do you mean to say that Artificial Organs is inessential?

Not at all. However, any artificial organ, to design, requires the expertise of specialists from a multitude of fields. Taking an example of artificial heart, one needs a cardiologist, an energy optimization specialist, an integrated circuits person, biomaterial expert and . In addition, one needs state of the art battery technology,