

BIOMEDICAL ENGINEERING: CHALLENGES AND OPPORTUNITIES

Raj Rangayyan

“University Professor”

Department of Electrical & Computer Engineering

ranga@ucalgary.ca

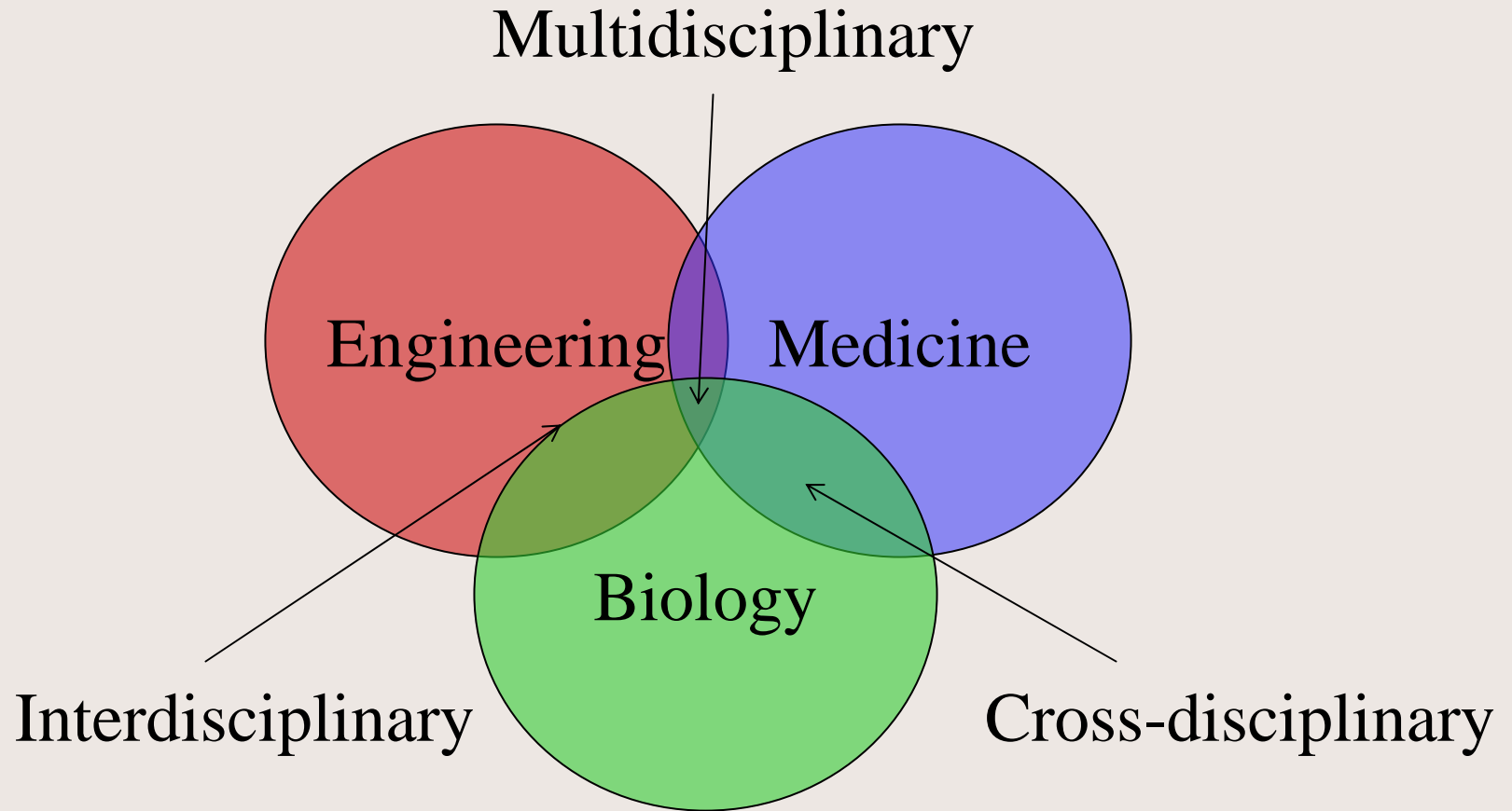


UNIVERSITY OF
CALGARY

SCHULICH
School of Engineering



The Nature of BME



Background Required: Related Areas of Study

- Physics and Chemistry
- Mathematics and Statistics
- Biology, Anatomy, Physiology, and Pathology
- Biochemistry
- Material Science
- Sensors and Instrumentation
- Basics of Engineering
- Basics of Medical Diagnosis and Therapy
- Information Processing and Analysis

Computer-aided Diagnosis

Related subject areas:

- *Biomedical Engineering and Medical Physics*
- *Diagnostic Medical Imaging and Radiology*
- *Digital Signal and Image Processing*
- *Pattern Analysis and Recognition*
- *Computer Vision*
- *Software Engineering*
- *Information and Communication Technology*
- *Biomedical Signal and Image Analysis*
- *Diagnostic Decision-making*

Objectives of Computer-aided Analysis of Mammograms

- Enhancement of image quality
- Detection of subtle signs of cancer
- Quantitative analysis of diagnostic features
- Objective aids to diagnostic decision
- Accurate, consistent, reproducible analysis
- *Earlier detection of breast cancer!*
- *Reduced morbidity and mortality!*

Applications of Computer-aided Diagnosis

- Screening program or diagnostic clinic
 - *Consultation by radiologists*
 - *Decision support*
 - *Second opinion*
 - *Content-based image retrieval:*
Comparative analysis with cases of known diagnosis
- Training
 - *Teaching, continuing medical education*
- Teleradiology, telemedicine
 - *When local expertise is not available*

Challenges in BME

- Grasping the terminology (jargon)
- Communicating across disciplinary boundaries
- Understanding the problem
- Appreciating the dynamic and unpredictable nature of biological systems
- Exchanging ideas openly with collaborators
- Identifying and exploring multiple solutions
- Accepting failure or rejection: ***Moving on!***

Cross-fertilization

Computed Tomography developed from research in

- radio-astronomy
- imaging of biological molecules
- nondestructive industrial testing
- crystallography
- mathematics of image reconstruction from projections

Sir Godfrey N. Hounsfield: Engineer won the 1979 Nobel Prize for Medicine!

Cross-fertilization

Medical imaging



Military

Detection of
tumors



Detection of
land mines

Infrared (thermal)
imaging for the
detection of
breast cancer



Night-vision
systems

Important Topics in BME Education

Excellent background required in:

- physics, chemistry, mathematics, biology
- anatomy, physiology, and pathology
- basics of instrumentation
- data analysis, statistics, signal processing, detection of events, decision-making
- illustrations with real-life data, signals, images, biomedical problems
- practical experience in problem solving.

Essential Elements in BME Education

- Hands-on experience with real-life data, signals, images, biomedical problems: *FUN!*
- Exercises on solving practical problems
- Visits to hospitals, clinical laboratories, industries
- Invited talks by practicing clinical specialists, hospital technologists, and entrepreneurs in BME
- Exposure to real-life clinical applications and problems, patient-related issues, development of BME tools and instruments.

Communication in BME

- Precise communication of engineering and technical methods.
- Accurate biomedical terminology.
- Appropriate presentation and interpretation of results.
- Need to address multiple, varied disciplines and professionals.
- Highly developed technical/ scientific writing and speaking skills.

Writing Research Papers in Biomedical Engineering

Introduction:

- Introduce the biomedical problem
- Give the scope and extent of the problem (epidemiology, statistics)
- Review previous approaches to address the problem
- State what is missing or lacking
- State your approach and indicate the expected benefits

Writing Research Papers in Biomedical Engineering

Methods:

- Introduce and describe your methods
- Avoid (minimize) jargon – make your writing understandable by a wide range of professionals
- Give adequate equations, flowcharts, and technical details so that other researchers may repeat and reproduce your work
- Explain the benefits of your approach as compared with those of other related methods

Writing Research Papers in Biomedical Engineering

Materials and Data:

- *Obtain approvals as required from ethics and other committees and indicate that this has been done*
- Explain the data collection procedures
- Specify the equipment used – manufacturer, location, model, etc.
- Give statistical details of patients or subjects involved – gender, mean and SD of age, nature of abnormality, etc.
- Explain and document the nature of data – number of samples, resolution, units, dimensions, etc.
- Give examples of data in plots, figures, images, etc.

Writing Research Papers in Biomedical Engineering

Results:

- Use running examples of different types to illustrate the functioning of your methods with real data and explain each step
- Discuss and interpret the results
- Use statistical and other means of analysis accepted and required in the specific field of application – p -values, receiver operating characteristics (ROC), classification accuracies, measures of reliability and robustness, computing times and complexity, etc.

Writing Research Papers in Biomedical Engineering

Discussion:

- Discuss the relevance of the results in the field of application
- Compare your results with those obtained by others in previously published works
- Discuss the limitations of your methods – sources of error or bias
- Discuss the limitations of your study – limited data, bias in data, nature of patient population used, etc.
- Perform a cost – benefit or risk – benefit analysis.

Writing Research Papers in Biomedical Engineering

Conclusion:

- Summarize your contribution to the field
- State the advantages of your methods
- State the benefits and relevance of your results
- Indicate potential applications
- Indicate potential future work

Writing Research Papers in Biomedical Engineering

References:

- Follow the format required by the specific journal or publication
- Ensure completeness and accuracy of each reference
- Give reference to your own related work and previous publications
- Ensure that you refer to all (or the most important) related work by other researchers

Writing Research Papers in Biomedical Engineering

Acknowledgments:

- All sources of financial or other support
- Individuals who provided minor assistance, data, administrative or technical support
- Organizations that provided support (other than the institutions of authors listed in the title)

Writing Research Papers in Biomedical Engineering

Quality of Writing:

- Use good style of scientific and technical writing – avoid loose and casual style
- Avoid errors in spelling, grammar, syntax, and semantics
- Be technically accurate and specific
- Take care of correct terminology
- ***Proofread, proofread, and proofread!***
- Consult collaborators and coauthors for help and contribution in the process of writing, reviewing, and proofreading

Writing Research Papers in Biomedical Engineering

Authorship:

- List authors in the order of their contribution to the paper (work)
- Each author *must* have contributed to the work in terms of ideas, supervision, implementation, data collection, analysis, or writing
- Each author *must* review the paper and be aware of submission of the paper

Desired Personal Traits (*Skill Set*)

- Recognizing your limitations
- Being open for collaborative team work:
being a part of the whole
- Being open to asking questions and
replying in simple & clear terms
- Appreciating the contributions of coworkers
- Respecting professional boundaries
- Developing good interpersonal skills

Opportunities

- Learn new areas of application of engineering and scientific endeavor
- Collaborate with professionals in other fields of research and investigation
- Contribute to another field with significant applications and benefit to the public
- Develop multidisciplinary perspective and problem-solving skills
- *Contribute to the well-being of people!*

Acknowledgments

- Alberta Heritage Foundation for Medical Research
- Natural Sciences and Engineering Research Council
- Alberta Breast Cancer Foundation
- University Technologies International Inc.
- Alberta Cancer Board
- Screen Test: Alberta Program for the Early Detection of Breast Cancer
- Arthritis Society of Canada
- Kids Cancer Care Foundation of Alberta