Systems & Biomedical
Engineering Dept.

Cairo University
Faculty of Engineering

Research Plan of the Department of Biomedical Engineering and Systems (2015-2018)

I. Main Research Thrusts

1. Medical Imaging Modalities: physics, instrumentation and computations.
Medical imaging modalities such as radiographic modalitites (x-ray and CT), nuclear imaging (SPECT and PET), ultrasound and Magnetic Resonance Imaging (MRI) as well as spectroscopy (MRS) are vital diagnostic tools in modern medicine. Ongoing research and development in this area requires both wide and in depth knowledge in various physics and engineering desciplines. New imaging methods as well as hybrid techniques are continuously explored to improve diagnostic accuracy and/or aid/evaluate treatment. Research in this multidisciplinary area includes areas of medical physics, instrumentation, modeling, reconstruction methods, computations, safety .... etc.

2. Biomedical Signal and Image Processing
This area includes the processing of the different one, two and multidimensional signals of interest to biomedical applications. This includes signal processing of physiological signals such as electrocardiography (ECG), electroencephalography (EEG), electromyography (EMG), etc. This includes also the processing of images obtained using medical imaging modalities such as ultrasound imaging, computed tomography, magnetic resonance imaging, etc. Several new applications in this area involve multidimensional signal processing such as functional imaging.

3. Medical Instrumentation
Other than medical imaging modalities medical instruments include vital sign monitors, life support machines, lab analyzers ... etc. This area addresses the design considerations and methodologies of medical devices and involves electronic design, mechanical design, biomechanics and rehabilitation engineering, safety design, fault tolerance/diagnosis, etc.

4. Clinical Engineering
This area addresses the basic design concepts of hospital environment including safety, organization, commissioning, management of medical technology, efficient hospital resource allocation, quantitative methods for medical equipment management including risk assessment, equipment replacement policies, optimal hospital space allocation, benchmarking equipment performance, and selection of appropriate technologies.

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5. Biomedical Pattern Recognition
This area involves the application of computational pattern analysis and artificial intelligence to allow the recognition of features in biomedical data. This includes several applications such as brain-computer interface, computer-aided diagnosis, biometrics, etc.

6. Health Informatics
This area includes the biomedical applications of computer science such as the design of hospital information systems, picture archiving and communication systems, clinical reporting tools, medical visualization, web-based clinics, etc.

7. Biomedical Modeling
This area involves the application of computer modeling techniques to build robust models for different biomedical applications such as cancer modeling, physiological system modeling, finite element modeling, etc.

8. Bioinformatics
This area involves the analysis of the genome and proteome data sets using concepts from computer science and signal processing. Example problems in this area involve genetic matching, gene prediction, fast archiving and search techniques for large data sets, data compression, protein-protein interaction prediction, in-silico experimentation, and gene regulatory networks.

9. Rehabilitation Engineering
Promotes the health and well-being of people with disabilities, improves human quality of life using a full range of systematic applications of engineering sciences to design, develop, adapt, test, evaluate, apply, and distribute technological solutions to problems confronted by individuals with disabilities.

II. Research Plan Including Ongoing and Future Research Topics

The Department of Biomedical Engineering and Systems has a tradition of doing world-class research with many several local and international award-winning faculty members. The body of research work in the department can be classified to belong to one of four categories:

A. **Theoretical basic academic research** involving theoretical derivation of new concepts/methodologies with broad application area that may extend to beyond biomedical applications.

B. **Applied academic research** involving real data and experimental work in biomedical applications with results directly applicable to these applications.

C. **Research and development** work that involves the development of a product for the local or international biomedical device industry.

D. **Investigative research** for consultation services where faculty members of the department are called upon by the government or local/international industry to investigate the source of a particular medical biomedical engineering related problem and propose solutions.

Research topics of interest in the next 3 years are:

Topic #	Research Topic	Category	Area
1	MRI and MRS	A/B/C	1
2	Radiographic imaging	A/B/C	1
3	Ultrasound imaging	A/B/C	1
4	ECG arrhythmia classification	B	2
5	EEG signal classification	B	2
6	Heart rate variability analysis	B	2
7	Sleep analysis	B	2
8	Brain-computer interface	B/C	5/7/9
9	3D reconstruction and visualization	B	1/2
10	Finite element modeling	A/B	1/7
11	Biomedical electromagnetics	A/B	1/7
12	Bioinformatics	A/B	2/5/6/8
13	Proteomics	A/B	2/5/6/8
14	Data mining	A/B	2/5/6/8
15	Gene regulatory networks	A/B	2/5/7
16	Computer aided diagnosis	A/B/C	2/5/6
17	Diagnostic expert systems	B/C	5/6
18	Image enhancement	A/B	2
19	Super-resolution imaging	A/B	2
20	Biomedical modeling	A/B	1/7
21	Medical informatics	B/C	6
22	Biometrics	B/C	2/5/7
23	Treatment planning	B/C	7
24	Embedded medical device design	B/C	1/3
25	Biomedical safety standards	C/D	1/3
26	Digital Doppler ultrasound	B/C	1/2/3
27	Biomedical data compression	A/B	2
28	Biomechanics and rehabilitation	B	3/9
29	RF identification for hospitals	C	4
30	Risk analysis in hospitals	B/D	4
31	Risk analysis of medical devices	B/D	4
32	Functional imaging	A/B	1/5/7
33	Multi-sensor fusion in medical devices	A/B	5/7
34	Artificial neural networks	A/B	5/7
35	Nonlinear dynamical modeling of biomedical systems	A/B	2/5/7
36	Biomedical ethics	D	1/4
37	Hospital commissioning	B/D	4
38	Picture archiving and communication system (PACS)	B/C	6
39	Hospital information system (HIS)	B/C	6
40	Mobile / base station radiation effects on humans	D	7
41	Real-time biomedical systems	B/C	1/5/7
42	Biomedical sensors	B	1/3/9
43	Big Data Analytics for Healthcare Applications	B/C	2/5/6/8

44	Body Area Networks	B/C	3/6/9
45	Quantitative methods for medical equipment management	B/D	4/3
46	Tissue characterization	A/B/C	1/2/3