COURSE PROGRAM *"FUNDAMENTALS OF BIOENGINEERING"*

Corso di Laurea Mag. in Ingegneria dell'Automazione e del Controllo dei Sistemi Complessi

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1. Basic Concepts of Biomedical Instrumentation

Generalized medical instrumentation system - Alternative operational mode - Medical measurement constraints - Classifications of biomedical instruments - Interfering and modifying input - Compensation techniques - Generalized static-dynamic characteristics - Design criteria - Commercial medical instrumentation development process - Regulation of medical device.

2. Basic Concepts of Bioelectricity

Structure and function of the Nervous System (central and peripheral), Nervous system cells (neuron, glial), how neurons transmit signals (cell membrane, protein channels, membrane potential, action potential, synaptic integration, AP propagation), How neuron communicate (chemical and electrical synapse, neuro-transmitter), Neuron electrical model (*Hodgkin-Huxley*, *Integrate and Fire*, *Hindmarsh-Rose*) and axon transmission model, How neuron can be recorded (multi-electrode array), Muscle action potential (coding sensory and motor information), Volume conductor fields/local field potential, Reflex arc, Electroneurogram (conduction velocity), Electromyography.
ElectroCardiogram (ECG)-Circulatory system and systemic parameter (blood pressure, blood velocity, cardiac output), heart anatomy, Heart electro/mechanical physiology, Membrane potential of the ventricular cell, ECG, Lead position, Arrhythmia (pacemaker abnormalities, conduction abnormalities), Ventricular assistant device and artificial heart, artificial blood.
Electromagnetic Activity of the Brain (EEG/MEG)- CNS anatomy (meninges, spinal cord, brainstem, cerebellum,cerebrum), Neocortex, biopotential from the brain (EEG/MEG), EEG/MEG recording and measurement, Brain rhythms, Abnormal Patterns (aging and brain disorder), Experimental protocol (Evoked potential),.
Fundamental of EEG/MEG signal processing: Independent Component Analysis (ICA), Principal Component Analysis (PCA), filtering and denoising, nonstazionarity, signal segmentation, signal transform and join time-frequency analysis, Coherency and Multivariate Autoregressive modeling (MAR), signal parameter estimation, classification algorithm, chaos and dynamical analysis.

3. Introduction to Biomedical Imaging

X-Ray Imaging- X-ray production (source, tube current, beam intensity, energy spectrum), Interaction of X-ray with tissue (coherent scattering, compton scattering, photoelectric effect), Linear and mass attenuation coefficient, Instrumentation for planar X-ray imaging (collimators, antiscattering grid, intensifying screen, X-ray film), Instrumentation for computed and digital radiography, Image characteristics (signal-to-noise ratio, spatial resolution, contrast-to-noise ratio), Contrast agents, X-ray Imaging methods (angiography, dual-energy, fluorscopy),Clinical applications (mammography, abdominal scans).
Computed Tomography (CT) –Scanner instrumentation, Detector for CT, Image Processing (pre-processing data correction, Radom transform and backprojection techniques, fan-beam reconstruction, iterative algorithm),Spiral/Helical CT , Multislice spiral TC, Radiation dose, Clinical Applications (cerebral scans, pulmonary disease, abdominal imaging).
Ultrasonic Imaging (US)- General principles of US, Wave propagation and characteristic acustic impedence, wave reflection and refraction, Energu loss mechanism in tissue (absorption, scattering, attenuation), Instrumentation (single –crystal trasducer, trasducer array, beam forming and time-gain compensation), Diagnostic mode (A-mode, M-mode, B-mode, 3D), Artifacts inUS, Image characteristics (signal-to-noise ratio, spatial resolution, contrast-to-noise ratio), Blood velocity measurement using US (doppler effect, continuous wave, pulsed mode, color doppler), Safety and bioeffect, Clinical applications (obstetrics, breast, musculoskeletal structure, cardiac disease).

4. Basic Concepts of Biostatistics

Biostatistics and Clinical practice How to summarize data-How to test for difference between groups (*ANOVA*)- The special case of two groups (*t-test*), Multiple comparison testing (*SNK test, tukey Test*), Multiple comparison against a single control (*Bonferroni t test, Dunnett's test*), How to analyze rates and proportions, Testing nominal data (*z test*, C*hi-Squre Test, Fisher Test*) – What does significant really means (Types of error *alfa* and *beta*) – Test Power (in *ANOVA* and *Chi-Squre Test*).

TESTI CONSIGLIATI:

- Webster J.G., *Medical Instrumentation: Application and Design*, WILEY, 1997
- Stanton A. Glantz, *Primer of Biostatistic*, McGRAW-HILL
- Andrew Webb, *Introduction of Biomedical Imaging*, IEEE press Series on Biomedical Eng., WILEY-INERSCIENCE
- Saeid Sanei, Jonathon Chambers, *EEG Signal Processing*, Wiley.
- Michael C. K. Khoo, *Physiological Control System*: A*nalysis, Simulation and Estimation*, IEEE press Series on Biomedical Eng., WILEY-INERSCIENCE