

DEPARTMENT OF BIOMEDICAL ENGINEERING

M. Tech. MEDICAL INFORMATICS

Program Structure (Applicable to 2023 admission onwards)

YEAR	FIRST SEMESTER						SECOND SEMESTER					
	SUB CODE	SUBJECT NAME	L	T	P	C	SUB CODE	SUBJECT NAME	L	T	P	C
I	MAT****	BIOSTATISTICS AND LINEAR ALGEBRA	4	0	0	4	BME****	DEEP LEARNING	4	0	0	4
	BME****	MACHINE LEARNING	4	0	0	4	BME****	ARTIFICIAL INTELLIGENCE IN MEDICAL INFORMATICS	4	0	0	4
	BME****	MEDICAL INFORMATION ANALYSIS	4	0	0	4	BME****	ELECTIVE I	4	0	0	4
	BME****	FEATURE ENGINEERING AND DATA MINING	4	0	0	4	BME****	ELECTIVE II	4	0	0	4
	BME****	DECISION SUPPORT SYSTEMS	4	0	0	4	BME****	ELECTIVE III	4	0	0	4
	HUM****	RESEARCH METHODOLOGY AND TECHNICAL COMMUNICATION*	1	0	3	-	****	OPEN ELECTIVE	3	0	0	3
	BME****	MACHINE LEARNING LAB	0	0	3	1	HUM****	RESEARCH METHODOLOGY AND TECHNICAL COMMUNICATION*	1	0	3	2
	BME****	FEATURE ENGINEERING LAB	0	0	3	1	BME****	DEEP LEARNING LAB	0	0	3	1
	BME****	BIOMEDICAL RESEARCH LAB 1	0	0	3	1	BME****	BIOMEDICAL RESEARCH LAB 2	0	0	3	1
	Total					23						27
	THIRD AND FOURTH SEMESTER											
II	BME****	PROJECT WORK							0	0	0	25

*TAUGHT IN BOTH SEMESTERS AND EVALUATED AND CREDITED IN THE SECOND SEMESTER

**LAB COURSES 2 & 3 AND 4&5 MAY BE COMBINED INTO ONE BY EITHER ALLOTING 6 Hrs/WEEK OR 3 Hrs/WEEK WITH A PROVISION FOR MINI PROJECT/ASSIGNMENTS

PROGRAM ELECTIVES		OPEN ELECTIVES	
		BME****	MEDICAL DATA INFORMATICS
BME****	INTERNET OF MEDICAL THINGS	BME 5051	PHYSIOLOGICAL CONTROL SYSTEMS
BME****	AUGMENTED REALITY AND VIRTUAL REALITY		
BME****	HEALTH INFORMATION SYSTEMS		
BME****	DIGITAL PATHOLOGY AND DIGITAL IMAGING		
BME****	INNOVATION AND ENTREPRENERSHIP		
BME****	BIOMETRICS FOR HEALTHCARE SYSYEM		
BME****	CLINICAL HEALTH CARE ANALYSIS		

SEMESTER 1

BME ****BIOSTATISTICS AND LINEAR ALGEBRA [4 0 0 4]

Vector Spaces, subspaces and linear transformations, matrices-basic operations, determinants, eigen values, eigen vectors, solution of a system of linear equations using matrices. Introduction to statistics and study design: Introduction, Types of variables- logarithmic transformations, graphical representation of data. Measures of central tendency, dispersion. Significance of statistics to biological problems, experimental studies; randomized controlled studies, historically controlled studies. Multivariate data- Correlation and simple linear regression: Karl Pearson correlation coefficient, Spearman Rank correlation coefficient, simple linear regression, regression model fit, Multiple linear regression models, random effects models Principles of statistical inference: Parameter estimation, hypothesis testing. Test statistics- t-test, F distribution, independent and dependent sample comparison, non-parametric tests-Wilcoxon Signed Rank Test, Wilcoxon Mann-Whitney Test. Basics of study design-cohort studies, case control studies, outcomes, odd ratio, and relative risks. Biological study designs- Concept of ANOVA using Completely randomized design, Random block design, stratified design factorial design, cluster design. Optimization strategies with case studies. SAS data set operations: Read raw data; write, merging, sub setting, sort, format data sets, output delivery system. SAS representations. SAS basic statistical procedure.

References

1. Biostatistics Alvin E. Lewis McGraw-Hill Professional Publishing 2013
2. Statistics and Numerical Methods in BASIC for Biologists J.D. Lee and T.D. Lee Van Nostr and Reinhold Company 1982
3. Statistical Analysis of Gene Expression Microarray Data T.P. Chapman CRC 2003
4. Matrix Algebra useful for Statistics, Second Edition, by Searle, S. R & Khuri A, I. (2017). John Wiley & Sons, New Jersey.

BME ****MACHINE LEARNING [4 0 0 4]

Introduction: Basic concepts- Supervised Learning, Discriminative Algorithms. **Supervised learning:** Supervised learning setup, LMS, Linear Algebra, Logistic regression. Perceptron. Exponential family, Generative learning algorithms. Gaussian discriminant analysis. Naïve Bayes, Support vector machines, Vectorization. **Practice ML advice:** Bias/variance tradeoff, Model selection and feature selection, Evaluating and debugging learning algorithms, Practical advice on structuring an ML project, Convex Optimization. **Unsupervised learning:** Clustering. K-means, EM. Mixture of Gaussians, Factor analysis, PCA (Principal components analysis), ICA (Independent components analysis), Applications.

SDL: SVM, PCA and applications*

Reference:

1. Aurélien Géron, Hands-On Machine Learning with Scikit-Learn and TensorFlow Concepts, Tools, and Techniques to Build Intelligent Systems. First Edition, 2017, Published by O'Reilly Media.
2. *Christopher Bishop, Pattern Recognition and Machine Learning (Information Science and Statistics), Springer; 1st ed. 2006. Corr. 2nd printing 2011 edition.
3. Stephen Marsland, Machine Learning: An Algorithmic Perspective, Chapman, and Hall/CRC; 2 Edition, 2014.
4. *Duda, Richard, Peter Hart, and David Stork. *Pattern Classification*. 2nd ed. New York, NY: Wiley-Interscience, 2007.

BME **MEDICAL INFORMATION ANALYSIS [4 0 0 4]**

Biomedical Signals and Images – ECG, EEG, EMG, Speech Signals, Speech Coding, Imaging Modalities, Surgical Applications. Fundamentals of Deterministic Signal and Image Processing – Data Acquisition, Transformations, Digital Filtering. Probability and Random Signals – Estimating PDFs, Blind source separation techniques. Image Segmentation and Registration, HIS, RIS and PACS and hospital patient workflow.

SDL: Case studies on ongoing applications on medical image analysis, PACS and hospital patient workflow*

References:

1. Oppenheim, A. V., and R. W. Schaffer, with J. R. Buck. Discrete-Time Signal Processing. 2nd ed. Upper Saddle River, NJ: Prentice-Hall, 1999. ISBN: 9780137549207.
2. Papoulis, A., and S. U. Pillai. Probability, Random Variables, and Stochastic Processes. New York, NY: McGraw Hill, 2001. ISBN: 9780072817256.
3. Gonzalez, R., and R. E. Woods. Digital Image Processing. 2nd ed. Upper Saddle River, NJ: Prentice-Hall, 2002. ISBN: 9780201180756.
4. *Rangaraj M Rangayyan, Biomedical Signal Analysis, 2nd edition, IEEE press, 2015
5. *Dougherty, Geoff, ed. Medical image processing: techniques and applications. Springer Science & Business Media, 2011.

BME **FEATURE ENGINEERING AND DATA MINING [4 0 0 4]**

Introduction to Data mining, Identification, Data Mining Metrics, Data Cleaning (pre-processing, feature selection, data, reduction, feature encoding, noise, and missing values, etc.), Key Issues, Opportunities for Data Mining. Feature engineering and analysis: Images, sampling, and frequency domain processing, Basic image processing operations, Low-level feature extraction (including edge detection), High-level feature

extraction: fixed shape matching, Application to image processing: High-level feature extraction: deformable shape analysis, Object description, Introduction to texture description, segmentation, and classification, Moving object detection and description.

Data Warehouse and OLAP Technology, Data Warehouse Architecture, Steps for the Design and Construction of Data Warehouses, A Three-Tier Data Warehouse Architecture, OLAP, OLAP queries, metadata repository, Data Pre-processing – Data Integration and Transformation, Data Reduction, Data Mining Primitives.

Mining Association Rules in Large Databases, Association Rule Mining, Market Basket Analysis, The Apriori algorithm, Generating Association Rules from Frequent Item sets, Efficiency of Apriori algorithm, Mining Frequent Item sets without Candidate Generation, Multilevel Association Rules, Approaches to Mining Multilevel Association Rules, Mining Multidimensional Association Rules for Relational Database and Data Warehouses, Multidimensional Association Rules, Mining Quantitative Association Rules, Mining Distance-Based Association Rules, From Association Mining to Correlation Analysis.

SDL: Application to image processing: High-level feature extraction: deformable shape analysis, Examples on Data Cleaning (pre-processing, feature selection, data, reduction, feature encoding, noise, and missing values, etc.) *

References

1. *M. Nixon and A. Aguado, “Feature Extraction and Image Processing”, Elsevier, ISBN 0-7506-5078-8
2. Charu C. Aggarwal, Data Mining: The Textbook, Springer, 2015
3. *P.-N. Tan, M. Steinbach and V. Kumar, Introduction to Data Mining, Wiley, 2005 (2nd ed. 2016)
4. Mohammed J. Zaki and Wagner Meira Jr., Data Mining and Analysis: Fundamental Concepts and Algorithms, Cambridge University Press, 2014
5. Hand David, Mannila Heikki, and Smyth Padhraic. Principles of Data Mining. Boston, MA: MIT, 2004. ISBN: 8120324579
6. Han, J., Kamber, M. & Pei, J. (2012). Data mining concepts and techniques, third edition, Morgan Kaufmann Publishers
7. Berry and Linoff. Mastering Data Mining. New York, NY: Wiley, 2000. ISBN: 0471331236.
8. Delmater and Hancock. Data Mining Explained. New York, NY: Digital Press, 2001. ISBN: 1555582311.

BME **DECISION SUPPORT SYSTEMS [4 0 0 4]**

Active Knowledge based system, which is developed using evidence-based medicine, with the computerized approach to improve patient care, Knowledge use, management, and representation. CDS methodology/functionality (disease / specialty based) and CDS standards. Computer-based Clinical Decision Support: Overview, Status, and Challenges, Features of CDSS, Mathematical Foundations of Decision Support

Systems, Data Mining and Clinical Decision Support Systems, Usability and Clinical Decision Support, Architectures for Clinical Decision Support.

Role of Quality Measurement and Reporting Feedback as a Driver for Care Improvement, Decision support delivered using the outpatient electronic health record, Knowledge for Clinical Decision Support: Statistical and Machine Learning Techniques, Evidence-Based Medicine, statistical methods in meta-analysis, Meta-analysis of complex datasets. Big Data and Population-Based Decision Support, Clinical Decision Support for Personalized Medicine, Decision Rules and Expressions, Formal methods for modelling. Best Practices for Implementation of Clinical Decision Support, National Policies on the Use of Clinical Decision Support, Ethical and Legal Issues in Decision Support, Evaluation of Clinical Decision Support, Adoption of Clinical Decision Support system, Decision Support for Patients, Diagnostic Decision Support Systems, Applications.

SDL: Systematic review pipeline, Population health decision support examples, Regulation and Law, Adoption of clinical decision support systems*

References:

1. Myriam Hunink and Paul Glaziou, “Decision Making in Health and Medicine”, 6th print 2007; Publisher: Cambridge University Press
2. *Berner, Eta S, “Clinical Decision Support Systems: Theory and Practice, (Ed.), 2nd ed., 2007, Publisher: Springer, Health Informatics Series (springer.com NOT springerpub.com)
3. Osheroff, Pifer, Teich, Sittig, Jenders, 2005; Publisher: Health Information and Management Systems Society (HIMSS)
4. *Robert Greenes Clinical Decision Support, The Road to Broad Adoption, 2nd Edition – March 26, 2014, eBook ISBN: 9780128005422, Hardcover ISBN: 9780123984760, Elsevier

HUM **RESEARCH METHODOLOGY AND TECHNICAL COMMUNICATION [1 0 3 2]**

Mechanics of Research Methodology: Basic concepts: Types of research, Significance of research, Research framework, Case study method, Experimental method, Sources of data, Data collection using questionnaire, Interviewing, and experimentation. Research formulation: Components, selection and formulation of a research problem, Objectives of formulation, and Criteria of a good research problem. Research hypothesis: Criterion for hypothesis construction, Nature of hypothesis, need for having a working hypothesis, Characteristics and Types of hypothesis, Procedure for hypothesis testing, Sampling methods- Introduction to various sampling methods and their applications. Data Analysis: Sources of data, Collection of data, Measurement and scaling technique, and Different techniques of Data analysis. Thesis Writing and Journal Publication: thesis writing, journal and conference papers writing, IEEE and Harvard styles of referencing, Effective Presentation, Copyrights, and avoiding plagiarism.

References

1. Dr Ranjit Kumar, Research Methodology: A Step-by-Step Guide for Beginners, SAGE, 2005.

2. Geoffrey R. Marczyk, David DeMatteo & David Festinger, Essentials of Research Design and Methodology, John Wiley & Sons, 2004.
3. John W. Creswel, Research Design: Qualitative, Quantitative, and Mixed Methods Approaches, SAGE, 2004
4. Suresh C. Sinha and Anil K. Dhiman, Research Methodology (2 Vols-Set), Vedam Books, 2006.
5. C. R. Kothari, Research Methodology: Methods and Techniques, New Age International Publisher, 2008

BME **MACHINE LEARNING LAB [0 0 3 1]**

This lab will involve experiments on regression, classification, and clustering problems. The practical session involves data modeling and predictions.

BME **FEATURE ENGINEERING LAB [0 0 3 2]**

Tableau, python are used for conducting the feature visualization, selection, and basic analysis of medical data. Involves data visualization and feature engineering case studies.

BME ** BIOMEDICAL RESEARCH LAB 1 [0 0 3 1]**

Student is assigned under a faculty for specific research topic in the related area of Medical Informatics. Students start their literature survey referring to journal papers on a specific topic in consultation with the mentor. Students are evaluated based on synopsis presentation, mid-term and final evaluation along with report. The evaluation is conducted by the assigned Faculty in consultation with program coordinator and the committee members.

SEMESTER 2

BME **DEEP LEARNING [4 0 0 4]**

Basics of artificial neural networks (ANN), Feedforward neural networks: Pattern classification using perceptron, Multilayer feedforward neural networks (MLFFNNs), Backpropagation learning, Deep neural networks (DNNs): Difficulty of training DNNs, Greedy layer wise, training, Optimization for training DNNs, Newer optimization methods for neural networks Second order methods for training, Convolution neural networks (CNNs), Deep CNNs, Different deep CNN architectures – LeNet, AlexNet, VGG, Training a CNNs: weights initialization, batch normalization,

hyperparameter optimization, Recurrent neural networks (RNNs), Long Short Term Memory (LSTM), Bidirectional LSTMs, Bidirectional RNNs, Generative models, Healthcare Applications and case studies

SDL: Linear Algebra, Regularization FOR DL, Practical methodologies, Deep generative models*

Reference: “Deep Learning”, An MIT Press book, Ian Goodfellow and Yoshua Bengio and Aaron Courville <http://www.deeplearningbook.org>

References:

1. Simon O. Haykin , “Neural Networks and Learning Machines” , 3rd Edition, Pearson, Prentice Hall, New Delhi, 2019
2. Sathish Kumar, “Neural Networks - A Classroom Approach”, McGraw Hill, 2nd Edition 2017.
3. B. Yegnanarayana, Artificial Neural Networks, Prentice- Hall of India, 2001
4. C.M. Bishop, Pattern Recognition and Machine Learning, Springer, 2006
5. S. N. Sivanandam, and S. N. Deepa, “Principles of Soft Computing”, Wiley India Pvt. Ltd., New Delhi, 2011.
6. Emmanuel C. Ifeakor, Piotr S Szczepaniak, Paulo J. G. Lisboa, “Artificial Neural Networks in Biomedicine”, Springer-Verlag London, 2000.
7. D L Hudson and M E Cohen, “Neural Networks and Artificial Intelligence for Biomedical Engineering”, IEEE Press Series on Biomedical Engineering, IEEE Press, IEEE Publications, U. S, 2000.
8. Utku Kose, Omer Deperlioglu, D. Jude Hemanth, Deep Learning for Biomedical Applications, ISBN 9780367422509, CRC Press, 2021
9. E. Golden Julie, Y. Harold Robinson, S. M. Jaisakthi. Handbook of Deep Learning in Biomedical Engineering and Health Informatics, CRC Press,202

BME **ARTIFICIAL INTELLIGENCE IN MEDICAL INFORMATICS [4 0 0 4]**

Artificial Intelligence (AI): Introduction, AI for Healthcare IT, Need for AI Operations, AI Healthcare Operations: Clinical Impact of AIOps, Design and Innovation, AIOps for Healthcare Delivery, Clinical AI, AIOps. Deploying AI in practice, Real world applications of AI in medicine., Automation, Workflow, Process, and Intelligence Design Security, Ethics of intelligence, Policy and law, confidentiality, privacy aspects of medical software development. The future of AI, The Convergence of Healthcare AI Technology. Case studies: AI for Electronic Health Records Data, AI and 2D Medical imaging data, 3D Medical imaging data, AI to wearable device data. Case studies.

SDL: Real world applications of AI in medicine, Case studies for AI *

References:

1. *Robert Shimonski, AI in healthcare, Wiley, 2020
2. Arjun Panesar, Machine learning & AI for healthcare, 1st Edition, Apress,2019
3. Ankur Saxena, Shivani Chandra, Artificial intelligence, and machine learning in healthcare, 2021.

BME **DEEP LEARNING LAB [0 0 6 2]**

Experiments involving neural network, Deep learning networks, and their architectures for different medical data analysis are included. (Using Python / AWS).

BME ** BIOMEDICAL RESEARCH LAB 2 [0 0 3 1]**

Students continue the research started during the first semester Biomedical Research Lab 1. The research output is either presented in conference or published in a Scopus indexed journal. Students are evaluated based on synopsis presentation, mid-term and final evaluation along with report. The evaluation is conducted by the assigned Faculty in consultation with program coordinator and the committee members.

PROGRAM ELECTIVES:

BME **INTERNET OF MEDICAL THINGS [4 0 0 4]**

Internet of Things: IoT Protocols, Logical Design, Enabling Technologies, Levels, IoT vs M2M, Design Methodology, Domain Specific Applications, Wireless Sensor Networks, Protocol Standards, Issues, Routing, Applications, Protocols: Bluetooth, Introduction, Protocol Stack, RF Classes, Radio Technologies, Service Discovery, Device Discovery, Profiles, Security (Discovering Bluetooth), Hardware, Zigbee, Frequency, Channels, Topology, Zigbee Protocol Stack, PHY, MAC Layer, Working, Frame Structure, Beacon, Non-Beacon Communication, Zigbee PDU, Zigbee Hardware, API Mode and AT mode communication, Internet Protocol, Introduction to IPv4 and IPv6, IPv4 Headers, Ipv6 Headers, 6LoWPAN, 6LoWPAN architecture: simple, extended and ad-hoc networks. Issues in determining IPv6 links in LLNs and illustration of the undetermined link addressing model. IPv6 addressing in 6LoWPAN. Sockets: Introduction to Sockets, Client Server Architecture, Unix Sockets, PORTS, Python APIs of Sockets, TCP socket programming using Python, UDP, RAW packets python programming. Healthcare applications.

SDL: Domain specific applications, Healthcare applications*

References:

1. *Arshdeep Bhaga, Vijay Madishetti, "Internet of things: A hands on Approach", Universities Press, ISBN:978172719547

2. Robert Faludi," Building Wireless Sensor Networks", Orielly, 2012
3. Jean-Philippe Vasseur, Adam Dunkels,"Interconnecting Smart Objects with IP: The Next Internet", Morgan Kaufmann Publishers,2010, ISBN:0123751659 9780123751652
4. Marco Schwartz, "Internet of Things with the Arduino Yun", Packt Publishing,2014
5. Charalampos Doukas,"Building Internet of Things with the Arduino: Volume 1", Create Space Independent Publishing Platform,2012
6. Houda Labiod, Hossam Afifi, Costantino De Santis, "Wi-Fi, Bluetooth, Zigbee and WiMAX", Springer Publications
7. Madhushree Ganguli, "Getting started with Bluetooth", Premier Press, 2002, ISBN 1931841837, 9781931841832.

BME **AUGMENTED REALITY AND VIRTUAL REALITY [4 0 0 4]**

Introduction to augmented reality (AR) and Virtual Reality (VR) interfaces. **Virtual Reality Module:** Definition and goals of Extended Reality, historical perspective, different applications of VR (news, sports, entertainment, surgery, training etc.), Psychology of VR: Place illusion, plausibility illusion, embodiment illusion, Graphics in VR: Transformations, 3D audio, Tracking in VR (Tilting/Yawing/SfM), general outline of content creation in VR. Interaction in VR: Natural Interaction, Magic/Active/Passive Interaction, Teleportation in VR, Virtual Navigation, redirected walking, walk-in-place, Interacting with objects in VR, hyper-natural interaction, evaluation metrics, physics-based interaction, state machines, User interfaces in VR: Abstract Interfaces, Diegetic/Non-diegetic interfaces, gestural interaction, issues in VR interaction, User Interfaces in Unity3D: Unity gesture plugin, Bespoke VR, Virtual Characters in VR, Body Animation in VR, Facial Animation, Social VR. **Augmented Reality Module:** Introduction to Augmented Reality, introduction to augmented reality frameworks (wikitude, ARCore, ARToolkit), Building AR in mobiles: Building an Android App in Unity3D, building an iOS app in Unity3D, Building AR experiences to Android/iOS, 2D image recognition and tracking (Camera representation, marker detection, post estimation), single image training and detection, shadows, occlusion, example projects, multiple image training and detection, tracking multiple markers, handling multiple trackers, GPS and compass integration, 3D Object Recognition and Tracking: Marker training, 3D object marker with occlusion, 3D scene recognition, Markerless Tracking: Getting started with instant tracking, adding physics simulation to a markerless environment, hiding and showing augmented objects

References:

1. Grigore C. Burdea, Philippe Coiffet, Virtual Reality Technology, Wiley 2016
2. Alan B. Craig, Understanding Augmented Reality, Concepts and Applications, Morgan Kaufmann, 2013.
3. Alan Craig, William Sherman and Jeffrey Will, Developing Virtual Reality Applications, Foundations of Effective Design, Morgan Kaufmann, 2009.
4. John Vince, "Virtual Reality Systems ", Pearson Education Asia, 2007.
5. Anand R., "Augmented and Virtual Reality", Khanna Publishing House, Delhi.
6. Peter Shirley, Michael Ashikhmin, and Steve Marschner, Fundamentals of Computer Graphics, A K Peters/CRC Press; 3rd edition, 2009.

BME **HEALTH INFORMATION SYSTEMS [4 0 0 4]**

Healthcare data, information & knowledge: Health information exchange; Health care data Standards & Quality; Technologies that support health informatics; Clinical and administrative application components; Different modules; Clinical data warehouses. Electronic health records (EHR): Key components; Computerized physician order entry; Clinical decision support system; Practice Management System & EHR; Electronic health record standards for India. Web-enabled technology applications: Telemedicine; Picture Archiving & Communication System; Mobile health; Consumer health informatics; Patient web portals: Personal Health Records; Public Health Informatics

Health information system adoption: Organizing information technology services; System development life cycle; System acquisition process; System implementation; System support and evaluation; Information technology alignment and strategic planning; Security of electronic data and networks: Health information Privacy; Health informatics Ethics; Transferring ethical responsibility; Health information Security; HIPAA security rules; Basic security Principles.

References

1. Hoyt, R.E., & Yoshihashi, A.K. (2014). Health Informatics: Practical Guide for Healthcare and Information Technology Professionals, (6th ed). Florida, USA: Informatics Education.
2. Wager, K.A., Lee, F.W., & Glaser, J.P. (2013). Health Care Information Systems: A Practical Approach for Health Care Management, (3rd ed). San Francisco, CA: Jossey-Bass

BME **DIGITAL PATHOLOGY AND DIGITAL IMAGING [4 0 0 4]**

Introduction to Pathology and Digital pathology; Radiology Vs. Digital pathology; Basics of Hematopathology, Histopathology; Benefits of digital pathology over the conventional diagnosis approach; Glass slides Vs. Digital slides; Applications of digital pathology over standard pathology practices; Telepathology applications; Digital pathology image capture - Digital microscope, Digital slide scanners; Process of blood smear slide preparation, blood smear image capture, and analysis; Demonstration on Blood slide preparation, Peripheral blood smear image capture using a digital microscope; Whole Slide Imaging (WSI) - major challenges to be addressed; The pyramidal format used in WSI and its significance; Standards for digital pathology and WSI - Image file formats, Compression schemes, Role of DICOM; Demonstration on WSI system; Digital pathology image analysis – Current technology and challenges, Case Studies; Applications of Machine/Deep learning in Digital pathology, Case Studies.

SDL: Telepathology*

References:

1. *Keith J. Kaplan, Luigi K.F. Rao, “Digital Pathology: Historical Perspectives, Current Concepts & Future Applications”, 1st ed. 2016 springer, ISBN-13: 978-3319203782, ISBN-10: 9783319203782
2. Yves Sucaet, Wim Waelput, “Digital Pathology, 2014 Edition, Springer

3. *Liron Pantanowitz and Anil V Parwani, “Digital Pathology”, American Society of Clinical Pathologists Press, ISBN-10: 0891896104, ISBN-13: 978-0891896104

Medical Imaging modalities: X-ray systems- generation, conventional detectors and flat panel detectors, diagnostic X-rays; Computed tomography: Principles of CT, data acquisition system, Different generations of CT geometries, image reconstruction algorithms; Positron Emission Tomography (PET): properties of radionuclides, Radionuclide production; principle of PET, PET detectors: Scintillation detectors, Radionuclide imaging systems; MRI: Principle of MRI, Longitudinal & transverse magnetization, T1 and T2 weighted images, MRI system; Ultrasound: Principles of ultrasonography, modes of operation: A-mode, B-mode, M-mode scanning, processing and display of ultrasound images; advancement in ultrasound imaging; Thermography: principles and applications; Data security and standards in healthcare.

SDL: Positron emission tomography*

1. *Smith NB, Webb A, “Introduction to medical imaging: physics, engineering and clinical applications”, Cambridge university press; 2011, ISBN: 9781139492041, 1139492047.

BME ***INNOVATION AND ENTREPRENEURSHIP [4-0-0-4]**

The Entrepreneurial Mind-Set, Startup Eco system, Corporate Entrepreneurship, Generating And Exploiting New Entries, Creativity and The Business Idea, Identifying and Analyzing Opportunities (Domestic and International), Protecting The Idea And Other Legal Issues For The Entrepreneur, The Business Plan, The Marketing Plan, The Organizational Plan, The Financial Plan, Sources of Capital, Informal Risk Capital, Venture Capital, Going Public, Strategies For Growth , Managing The Implications of Growth, Accessing Resources For Growth From External Sources, Succession Planning.

References

1. Hisrich, R D., Peters, M P, Shepard D A, Sinha. S. Entrepreneurship (11e), McGraw-Hill Special Indian Edition, 2020
2. Murray, E L., Neck, H M., Neck, C P. Entrepreneurship: The Practice and Mindset (2 edition) Sage Publication
3. Norman S and Cornwall J Essentials of Entrepreneurship and Small Business Management, Pearson Publication
4. Robert D Hisrich, M P Peters, D A Shepherd, Entrepreneurship, McGraw Hill, 10th edition (2017)
5. Rajeev Roy, Entrepreneurship, Oxford Higher Education, 2nd edition (2011)
6. David H Holt, Entrepreneurship: New Venture Creation, Prentice Hall (2019)

BME ***BIOMETRICS FOR HEALTHCARE SYSEM [4-0-0-4]**

Basic image operations, Interpolation, Special filters, enhancement filter, Edge detection, thresholding, localization. Introduction of biometric traits and its aim, Biometric system, authentication, physiological and behavioral properties, Identification and verification, Threshold, Score distribution, FAR and FRR, System design issues - Expected overall error, EER, ROC curve, DET curve, FAR/FRR curve. Existing Biometric Technologies: Fingerprints, Face, Iris, Hand Geometry, Ear, Voice, Retina, Gait. Introduction to physiological and behavioral biometrics in hospitals or care units, Biometric authentication based on ECG, EMG, and Phonocardiograph (PCG) signals. Multimodal identification and Verification system, normalization strategy, Fusion methods, Biometric system security. Face and ECG Based Multimodal Biometric Authentication.

References:

1. Girija Chetty and Jucheng Yang, *Advanced Biometric Technologies*, InTech, 2011.
2. Jain, A.K., Ross, A., Nandakumar, K. *Introduction to Biometrics*. Springer; 2011 edition.
3. David Zhang, Fengxi Song, Zhizhen Liang, Yong Xu, *Advanced Pattern Recognition Technologies with Applications to Biometrics (Premier Reference Source)*, Medical Information Science Reference; 1st edition, 2009.
4. Ruud M. Bolle, Sharath Pankanti, Nalini K. Ratha, Andrew W. Senior, Jonathan H. Connell *Guide to Biometrics*, By, Springer, 2009.
5. Duda, Richard, Peter Hart, and David Stork. *Pattern Classification*. 2nd ed. New York, NY: Wiley-Interscience, 2007.
6. Rafael C. Gonzalez, Richard Eugene Woods, *Digital Image Processing using MATLAB*, 2nd Edition, Tata McGraw-Hill Education 2010.

BME**CLINICAL HEALTH CARE ANALYSIS [4-0-0-4]**

Introduction of clinical health care data sources and basic analytics, Electronic health record systems, digital framework, clinical intelligence, role of analytics in supporting a data-driven "learning healthcare system", The value-driven healthcare system, measuring health system performance, existing quality/performance measurement frameworks (NQF, HEDIS), comparing healthcare delivery, attributes of high performing healthcare systems, definition and scope of business and clinical intelligence, key components of healthcare analytics, and the IT infrastructure and human capital needed to leverage analytics for health improvement. Introduction to business intelligence and healthcare, data warehouse, BI architecture, data protection: Security, confidentiality, and privacy aspects of medical software development, spyware and malware protection, Privacy Issues in Medical Image Analysis, Privacy in Internet of Healthcare Things, Health Device Security and Privacy Challenges of Implementing Privacy Policies Across the Globe, the Role of Law in Protecting Medical Data.

1. Bob Kelley., "Healthcare Data Analytics: Primary Methods and Related Insights". September 23, 2019, | ISBN-10: 1694588742 | ISBN-13: 978-1694588746
2. Ross M. Mullner, Edward M. Rafalski, "Healthcare Analytics: Foundations and Frontiers", Taylor & Francis, 2019
3. Chandan K. Reddy, Charu C. Aggarwal, "Healthcare Data Analytics", CRC Press, 2020
4. Laura B. Madsen, "Healthcare Business Intelligence", John Wiley & Sons Inc, John Wiley & Sons Inc.
5. Shilpa Balan, Joseph otto, "Business Intelligence in Healthcare with IBM Watson Analytics", CreateSpace Independent Publishing Platform, ISBN: 9781548829896, 9781548829896
6. Laura B Madsen, "Data Driven Healthcare", Wiley India; 1 edition (2015), ISBN-10: 8126554169, ISBN-13: 978-8126554164
7. Cynthia McKinney, Ray Hess, Mike Whitecar, "Implementing Business Intelligence in Your Healthcare Organization", HIMSS Book Series, 1st Edition, ISBN-13: 978-0984457755, 2012
8. Ahmed Elngar, Ambika Pawar, Prathamesh Churi, "Data Protection and Privacy in Healthcare Research and Innovations", CRC press, 2021

OPEN ELECTIVE

BME**MEDICAL DATA INFORMATICS [3 0 0 3]**

Introduction to biomedical data, medical data acquisition, storage, and use, decision making: probabilistic clinical reasoning, cognitive science, computer architectures for health care and biomedicine, standards in biomedical informatics, biomedical imaging informatics, ethics and biomedical and health informatics: users, standards, and outcomes.- evaluation of biomedical and health information resources, electronic health record system, the health information infrastructure, management of information in health care organization, patient-centered care systems, public health informatics, consumer health informatics and personal health records, tele-health, patient monitoring systems, imaging systems in radiology, information retrieval and digital libraries, clinical decision-support systems, computers in health care education, bioinformatics, clinical research informatics, health information technology policy, the future of informatics in biomedicine.

Reference:

1. Shortliffe E, "Biomedical Informatics Computer Applications in Health Care and Biomedicine", Springer, 5th Ed 2021.
2. Alain Venot, Anitha B., Catherine Q., "Medical Informatics", E-Health, Springer, 2021

BME ** PHYSIOLOGICAL CONTROL SYSTEMS [3 0 0 3]**

Introduction to Technological Control System, Transfer functions, Mathematical Approaches, System Stability, Feedback Concept and Stability Analysis. Introduction to Biological Control System, similarities and differences, Transfer of substances between compartments, Biological receptors, characteristics, Regulation of acid-base balance, Endocrine Control, Regulation of Extra Cellular Water and Electrolyte. Introduction to Various Process Controls like Cardiac Rate, Blood Pressure, Respiratory Rate and Blood Glucose Regulation. Modelling of Human Thermal Regulatory System, Parameters Involved, Control System Models etc. Biochemistry of Digestion. Type of Heat Loss from the Body, Model of Heat Transfer between Subsystems of Human Body like Skin, Core, etc, Respiratory control system, Modelling of O₂ Uptake, Mass Balancing by Lungs, Gas Transport Mechanism of Lungs, O₂ and CO₂ Transport in Blood and Tissue. Introduction to Eye Tracking and Control. Cardio Vascular Control system, pupil control system, MATLAB applications in control systems.

References:

1. H.T. Milhorn, "The Applications of Control Theory to Physiological System", W.B. Saunders, 1966.
2. J. H... Milsum, Biological Control System Analysis, McGraw Hill, 1966.
3. B.C. Kuo, Automatic Control System, 9th edition, Prentice Hall, 2009.