



**M.Sc in Computer Science**  
**with specialization in**  
**Networking and Cyber Security/ Data Analytics**

Faculty of Science  
Department of Computer Science  
St. Xavier's University, Kolkata

## M.Sc Computer Science - Curriculum

### **Programme Educational Objectives**

**PEO 1:** Providing a strong foundation on theoretical aspects of Computer Science by strengthening mathematical and scientific competencies

**PEO 2:** Acquiring expertise in latest technological tools for development and experimentation

**PEO 3:** Building cutting-edge solutions to challenging societal problems that meets industry-standards

**PEO 4:** Forming research bent of mind in areas of interest

**PEO 5:** Encouraging students to take up higher education, research and entrepreneurship

### **Programme Outcomes**

**PO 1:** Ability to apply mathematical, statistical and programming knowledge to tackle challenging problems

**PO 2:** Gaining keen understanding of the hardware aspect of a system and its relationship with software

**PO 3:** Conducting rigorous experimentation to analyze and interpret data

**PO 4:** Building models which are technically robust and in-line with best computing practices

**PO 5:** Understanding the internal details of a computational process for identification and correction of erroneous scenarios

**PO 6:** Analyzing the proposed solution to a problem based upon well-defined computational parameters

**PO 7:** Learning to document research findings in a scientific and systematic manner

**PO 8:** Recognizing learning as a lifelong process and the need to be self-taught

**M.Sc. Computer Science with specializations in:**

1. Networking and Cyber Security
2. Data Analytics

Total Marks: 2400

Total Credit: 96

**Semester wise Details**

<b>Semester-I</b>							
<b>Number of Papers: 5</b>							
Course code	Course Title	Course Type	Credits in each course				Total Marks
			Theory	Practical	Tutorial	Credits	
MCSR110C	Advanced Analysis of Algorithm	Core	3	2	0	5	[20(CIA) + 40(T)] + 40(P)
MCSR120C	Distributed System	Core	3	2	0	5	[20(CIA) + 40(T)] + 40(P)
MCSR130T	Automata and Compiler Design	Core	4	0	0	4	20(CIA) + 80(T)
MCSR140C	Statistical Analysis using Python	Core	2	3	0	5	[20(CIA) + 30(T)] + 50(P)
MCSR150C	Artificial Intelligence and Soft Computing	Core	3	2	0	5	[20(CIA) + 40(T)] + 40(P)
<b>Total</b>			<b>15</b>	<b>9</b>	<b>0</b>	<b>24</b>	<b>500</b>

<b>Semester-II</b>							
<b>Number of Papers: 6</b>							
Course code	Course Title	Course Type	Credits in each course				Total Marks
			Theory	Practical	Tutorial	Credits	
MCSR210C	Cryptography and Cryptanalysis	Core	3	1	0	4	[20(CIA) + 60(T)] + 20(P)
MCSR220C	Machine Learning	Core	3	2	0	5	[20(CIA) + 40(T)] + 40(P)
MCSR230C	Embedded and Real Time Systems	Core	2	2	1	5	[20(CIA) + 40(T)] + 40(P)
MCSR240C	Advanced Software Engineering	Core	3	2	0	5	[20(CIA) + 40(T)] + 40(P)
MCSR250C	Operation Research and Research Methodology	Core	3	2	0	5	[20(CIA) + 40(T)] + 40(P)
<b>Total</b>			<b>14</b>	<b>9</b>	<b>1</b>	<b>24</b>	<b>500</b>

<b>Semester-III</b>							
<b>Number of Papers: 5+2</b>							
Course code	Course Title	Course Type	Credits in each course				Total Marks
			Theory	Practical	Tutorial	Credits	
MCSR310C	Computer Vision	Core	3	2	0	5	[20(CIA) + 40(T)] + 40(P)
MCSR320C	Data Warehouse and Mining	Core	3	2	0	5	[20(CIA) + 40(T)] + 40(P)
MCSR330T	Mobile and wireless Computing	Core	2	0	0	2	20(CIA) + 80(T)
<b>Specialization Bucket: 01 (Networking and Cyber Security)</b>							
MCSR341T	Cloud Computing	Core	4	0	0	4	20(CIA) + 80(T)
MCSR351T	Network Security		4	0	0	4	20(CIA) + 80(T)
<b>Specialization Bucket: 02 (Data Analytics)</b>							
MCSR342T	Business Intelligence	Core	4	0	0	4	20(CIA) + 80(T)
MCSR352T	Deep Learning		4	0	0	4	20(CIA) + 80(T)
MCSR360P	Smart Analytics System Design	Core	0	2	0	2	20(CIA) + 80(P)

	Lab						
MCSR370J	Project – Phase 1	Core	0	0	2	2	20(CIA) + 80(J)
<b>Total</b>			<b>16</b>	<b>6</b>	<b>2</b>	<b>24</b>	<b>700</b>

<b>Semester–IV</b>							
<b>Number of Papers: 3+3</b>							
Course code	Course Title	Course Type	Credits in each course				Total Marks
			Theory	Practical	Tutorial	Credits	
<b><i>Specialization Bucket: 01 (Networking and Cyber Security)</i></b>							
MCSR411T	Security for Business Infrastructure, Cyber Law and Ethics	Core	4	0	0	4	20(CIA) + 80(T)
MCSR421T	Security for Cyber-Physical Systems		4	0	0	4	20(CIA) + 80(T)
MCSR431T	IOT and Smart Systems		4	0	0	4	20(CIA) + 80(T)
<b><i>Specialization Bucket: 02 (Data Analytics)</i></b>							
MCSR412T	Bio-informatics	Core	4	0	0	4	20(CIA) + 80(T)
MCSR422T	NLP and Text Analytics		4	0	0	4	20(CIA) + 80(T)
MCSR432T	Social Network Analytics		4	0	0	4	20(CIA) + 80(T)
MCSR440J	Term Paper	Core	0	0	2	2	20(CIA) + 80(P)
MCSR450J	Project – Phase II **	Core	0	0	8	8	40(CIA) + 160(P)
MCSR460V	General Viva-Voce	Core	0	0	2	2	20(CIA) + 80(P)
<b>Total</b>			<b>12</b>	<b>0</b>	<b>12</b>	<b>24</b>	<b>700</b>

\*CIA: Continuous Internal Assessment, T: Theory, P: Practical and C: Combine

\*\* Publication of at least ONE research paper in UGC recognized Journal is Desirable.

# M.Sc Computer Science - Detailed Syllabus

## Detailed Syllabus – Semester 1

### **MCSR110C: Advanced Analysis of Algorithm**

#### **Unit I: Introduction**

Definition of algorithms, Characteristics of algorithms, Types of algorithms: Recursive, Non-recursive

#### **Unit II: Performance evaluation of Algorithms**

Efficiency of an algorithm in terms of space and time, Asymptotic notation (Big-O, Big-Omega, Big-Theta, Small-O, Small-Omega), Best Case, Worst Case, Average Case, Recurrence Relations, Master's Theorem for Recursive Algorithms

#### **Unit III: Divide and Conquer Paradigm**

Binary Search, Quick Sort, Merge Sort, Strassen's Algorithm for Matrix Multiplication

#### **Unit IV: Greedy Paradigm**

Knapsack problem, Huffman Coding, Job Sequencing problem, Activity Selection Problem

#### **Unit V: Dynamic Programming Paradigm**

Fibonacci Sequence, Longest Common Sub Sequence, Matrix Chain Multiplication, Subset Sum Problem

#### **Unit VI: Graph Algorithms**

Traversal algorithms: BFS, DFS, Minimal Spanning Tree algorithms: Prim's, Kruskal's, Single Source Shortest Path Algorithms: Dijkstra's, Floyd Warshall, Topological Sort

#### **Unit VII: Classification of problems**

Concept of P, NP, NP-hard, NP-complete, SAT Problem, Cook's Theorem

For the practical portion, the following topics are to be covered:

1. Implementation of Divide and Conquer problems such as Binary Search, Quick Sort, Merge Sort
2. Implementation of Greedy problems such as Knapsack and Huffman Coding
3. Implementation of DP problems such as Matrix Chain Multiplication and Subset Sum Problem
4. Implementation of Graph algorithms such as BFS, DFS, Prim's Kruskal's among others

### **Suggested Books**

1. T. H. Cormen et al -Introduction to Algorithms , PHI
2. E. Horowitz, S. Sahani - Fundamentals of Computer Algorithms – Galgotia
3. Bratley et al - Fundamentals of Algorithms-PHI

### **MCSR120C: Distributed Systems**

#### **Unit I: Introduction**

Definition of Distributed System, Difference with Centralized System, Advantages and Disadvantages

#### **Unit II: Communication in Distributed Systems**

Review of the OSI Model, Client Server Model, Remote Procedure Call

#### **Unit III: Synchronization in Distributed Systems**

Clocks, Centralized, Distributed and Token Ring Algorithms for Mutual Exclusion, Bully and Ring Algorithms for Election, Deadlocks in Distributed Systems and comparison with Centralized Systems

## **Unit IV: Processes and Processors in Distributed Systems**

Threads, System Models, Processor Allocation, Scheduling, Fault Tolerance

## **Unit V: Distributed File Systems**

Design, Implementation and Trends in Distributed File Systems

## **Unit VI: Distributed Shared Memory**

Definition of shared memory, Consistency Models, Page-based distributed shared memory

For the practical portion, special reference may be given to Operating System as a concurrent program in UNIX environments

## **Suggested Books**

1. Tanenbum,A.S., Distributed Operating Systems ,Pearson Education.
2. Singhal,Shivaratri, Advanced Concepts in Operating Systems, TMH.
3. P.K.Sinha, Distributed Operating Systems, PHI
4. D.M. Dhamdhere, Operating Systems – A Concept Based Approach, Second Edition, TMGH, 2006, New Delhi

## **MCSR130T: Automata and Compiler Design**

### **Unit I: Introduction to Automata Theory**

Definition of automaton, Alphabet, Language, Finite Automaton (DFA, NFA, Epsilon-NFA, Mealy Machine, Moore Machine), Construction of Finite Automata from language, Conversion of NFA to DFA, Minimization of DFA, Construction of Mealy and Moore Machines from language, Inter-conversion of Mealy and Moore Machines

### **Unit II: Families of Formal Languages**

Regular expressions, Examples of regular expressions, Identities of regular expressions, Testing whether a language is regular or not, Examples of regular languages

### **Unit III: Grammar**

Definition, Chomsky's Classification of Grammars, Grammar as a generator of languages, Elimination of parameters from CFG (null productions, unit productions, useless symbols), Representation of CFG (CNF, GNF)

### **Unit IV: Phases of Compilation**

Definition of compiler, Different phases of compilation, Symbol Table, Ambiguous grammars and making them unambiguous, Elimination of left recursion, Elimination of non-determinism

### **Unit V: Parsers**

Recursive descent, LL(1), LR(0), SLR(1), LALR(1), CLR(1)

## **Suggested Books**

1. Introduction to Automata Theory, Languages, and Computation by John E. Hopcroft, Rajeev Motwani, Jeffrey D. Ullman, 3rd Edition, Pearson.
2. Theory of Computer Science (Automata, Languages & Computation) by K L P Misra & N Chandrasekharan, 3rd Edition, PHI.
3. Switching and Finite Automata Theory by ZviKohavi, Niraj.K.Jha, 3rd Edition, TMH.
4. Formal Language and Automata, P. Linz, Narosa

## **MCSR140C: Statistical Analysis using Python**

### **Unit I: Exploratory Data Analysis**

Introduction to IRIS dataset, Scatter plots (2-D, 3-D), Pair Plots, Histogram, Probability Density Function (PDF), Univariate Analysis, Cumulative Distribution Function (CDF), Mean, Variance, Standard Deviation, Median,

Percentiles, Quartiles, Inter quartile range, Median Absolute Deviation, Box plot with whiskers, Violin plots, Contour plot for multivariate analysis

### **Unit II: Applied Probability and Statistics**

CDF of Gaussian Distribution, Symmetric distribution, Skewness, Kurtosis, Standard Normal Variable, Standardization, Kernel Density Estimation (KDE), Sampling Distribution, Central Limit Theorem, Q-Q Plot, Chebyshev's Inequality, Discrete and Continuous Uniform Distributions, Log Normal Distributions, Power law distributions, Box Cox transforms, Co-variance, Pearson Correlation Coefficient, Spearman Rank Correlation Coefficient, Confidence Interval, Hypothesis Testing, Resampling and permutation testing, K-S Test

### **Unit III: Dimensionality Reduction**

Data matrix, Feature Normalization, Mean and Co-variance of Data Matrix, Column Standardization, Demonstration on MNIST Dataset of Handwritten digits, Principal Component Analysis (PCA) as a tool for dimensionality reduction and visualization, t-SNE as a tool for dimensionality reduction and visualization

For the practical portion, all statistical techniques are to be covered on popularly available data sets or synthetic data sets created using random values

### **Suggested Books**

1. Practical Statistics for Data Scientists, 2e: 50+ Essential Concepts Using R and Python by Peter Bruce, Andrew Bruce, Peter Gedeck, O'Reilly
2. Head First Statistics: A Brain-Friendly Guide by Dawn Griffiths, O'Reilly
3. Think Stats: Exploratory Data Analysis, Second Edition by Allen Downey, O'Reilly

## **MCSR150C: Artificial Intelligence and Soft Computing**

### **Unit I: Introduction**

Definition, Importance of AI in fields of education, healthcare, medicine, environment, Advantages and disadvantages of AI, AI as a superset of Machine Learning, Data Science and Deep Learning

### **Unit II: State Space search**

State Space Graphs, Implicit and explicit graphs, Production Systems, formulating the state-space; Uninformed search: breadth first search, depth first search; Uniform cost algorithm; Informed search: use of heuristics, A\* algorithm, Admissibility of A\*; Analysis and comparison of search algorithms.

### **Unit III: Adversarial Search**

Two agent games, AND/OR graphs, Min-max procedure, and game trees, Alpha – Beta pruning procedure, learning evaluation functions.

### **Unit IV: Constrained Satisfaction Search**

Introduction to Constrained Satisfaction search (CSP), Applications, Algorithms to CSPs, Symbolic constraints and propagation.

### **Unit V: Fuzzy Systems**

Introduction to fuzzy logic, Fuzz set v/s Crisp set, Fuzzy relation, Fuzzy set operations, Entropy of fuzzy set, Composition of fuzzy set, Properties of fuzzy set, Defuzzification

### **Unit VI: Soft Computing**

Definition, Comparison with traditional computing, Characteristics, Applications

### **Unit VII: Neural Networks**

History of neural network and Deep Learning, Working of biological neurons, Growth of biological neural networks, Perceptron, Multi-layer Perceptron (MLP), Training an MLP, Backpropagation, Activation functions, Vanishing

gradient problem, Bias-Variance tradeoff

For the practical portion, the following topics are to be covered:

1. Logic programming using PROLOG or LISP
2. Implementing Neural Networks from scratch using Python

### **Suggested Books**

1. Elaine Rich and Kevin Knight: Artificial Intelligence, TMH
2. Dan W. Patterson: Introduction to Artificial Intelligence and Expert Systems, PHI
3. S. Russel and P. Norvig, "Artificial Intelligence, A modern Approach"

## **Detailed Syllabus – Semester 2**

### **MCSR210C: Cryptography and Cryptanalysis**

#### **Unit I: Introduction**

Dimensions of Security, Classification of attacks, Definition of Cryptography, Advantages of Cryptography, Applications of Cryptography in the modern-era, Real-world case studies on use of cryptography, Cryptography v/s Network Security

#### **Unit II: Mathematics behind Symmetric Key Cryptography**

Set of Integers, Binary Operations on Integers, Modular Arithmetic, Matrices, Determinants, Linear Congruence, Group, Ring, Field

#### **Unit III: Symmetric Key Ciphers**

Substitution Ciphers (Mono-alphabetic ciphers, Poly-alphabetic ciphers), Transposition Ciphers (Keyless, Keyed), Stream Ciphers, Block Ciphers, DES, AES

#### **Unit IV: Mathematics behind Asymmetric Key Ciphers**

Prime Numbers, Euler's Phi Function, Fermat's Little Theorem, Euler's Theorem, Factorization, Chinese Remainder Theorem,

#### **Unit V: Asymmetric Key Ciphers**

Keys, Trapdoor One-way function, RSA Cryptosystem

#### **Unit VI: Integrity, Authentication, Key Management**

Hash Functions, Digital Signature, Passwords, Kerberos

For the practical portion, the following topics are to be covered:

1. Encryption/Decryption using Caesar Cipher, Substitution Cipher and Hill Cipher
2. Implementation of DES algorithm
3. Implementation of RSA algorithm
4. Implementation of Diffie-Hellman Key Exchange mechanism
5. Implementation of One Time Password mechanism

### **Suggested Books**

1. Computer Security: Art and Science, M. Bishop, Pearson Education.
2. Information Security: Principles and Practice, M. Stamp, John Wiley & Sons.
3. Cryptography and Network Security, William Stallings, Eastern Economy Edition, PHI.
4. Cryptography and Network Security, Behrouz A Forouzan, McGraw Hill Education.



## **MCSR220C: Machine Learning**

### **Unit I: Classification and Regression Models: KNN**

How classification works, Data Matrix Notation, Classification v/s Regression (examples), KNN intuition, Failure cases of KNN, Distance measures: Euclidean, Manhattan, Minkowski, Hamming, Cosine Distance and Cosine Similarity, Measuring effectiveness of KNN, Test/Evaluation time and Space Complexity, KNN Limitations, Decision surface for KNN as K changes, Overfitting and Underfitting, Cross validation, KNN for regression,

### **Unit II: Performance measurement of Models**

Accuracy, Confusion Matrix, ROC Curve, AUC, Log-loss, Coefficient of determination, Median Absolute Deviation, Distribution of errors

### **Unit III: Classification algorithms in various situations**

Imbalanced v/s Balanced datasets, Multi-class classification, Train and Test set differences, Impact of outliers, Local outlier factor, Reachability distance, Impact of scale and column standardization, Feature importance and Forward Feature Selection, Handling categorical and numerical features, Handling missing values, Curse of Dimensionality, Bias-Variance trade-off

### **Unit IV: Algorithms**

Naive Baye's, Logistic Regression, Linear Regression, SVMs, Decision Trees, Ensemble Models

### **Unit V: Case Study**

Marketing Attribution using Mathematical Models, Quora Question Pair Similarity Problem, Personalized Cancer Diagnosis, Stack Overflow Tag Predictor, Microsoft Malware Detection

For the practical portion, the case studies listed under **Unit V** are to be implemented

## **Suggested Books**

1. Machine Learning by Tom M. Mitchell, TMH
2. Machine Learning by Saikat Dutt et al , Pearson
3. Introduction to Machine Learning with Python: A Guide for Data Scientists by Andreas Muller, O'Reilly
4. Hands-On Machine Learning with Scikit-Learn, Keras and Tensor Flow: Concepts, Tools and Techniques to Build Intelligent Systems by Aurelian Geron, O'Reilly
5. Deep Learning (Adaptive Computation and Machine Learning Series) by Ian Goodfellow, et. al, The MIT Press

## **MCSR230C: Embedded and Real Time Systems**

### **Unit I: Introduction to 8051**

Overview of Microcontroller, Memory, I/O interface Intel Microcontroller 8051: Architecture, Peripheral Interface Controller (PIC)

### **Unit II: Assembly Language Programming**

Instruction set, Addressing Modes, Jump, Loop and Call instructions, I/O Manipulation, Serial communication, Arithmetic and logical instructions.

### **Unit III: Introduction to Embedded System Programming**

Data types and time delays, I/O programming, Logic operations, Data conversions, Data serialization, Interrupt programming, LCD and Keyboard interfacing, ADC, DAC, sensors interfacing, interfacing 8255, I/O interfacing for 8051, interfacing 8255, 8257, 8259/ 8279, ADC, DAC, Motor control using 8051 C.

### **Unit IV: Programmable logic devices and Hardware description Language**

PAL, PLA, PLD, ASIC, FPGA

### **Unit V: Hardware Description Language (VHDL)**

Basic Terminology, Entity Declaration, Architecture body, Configuration and package declaration, Package body, Model analysis and Simulation. Basic Language elements, Behavioral Model, Dataflow Model, Structural Model, Subprogram and overloading, Applications.

For the practical portion, the following points are to be covered:

1. Assembly language programming using 8051 microcontroller
2. VHDL Programming

### **Suggested Books**

1. Ray, Bhurchandi ,Advanced Microprocessors and Peripherals, TMH
2. Mazidi, McKinlay, The 8051 Microcontroller and Embedded Systems, Pearson – Prentice Hall
3. Barry Brey, The Intel Microprocessors: TMH
4. Computers as Components: Principles of Embedded Computing System Design (The Morgan Kaufmann Series in Computer Architecture and Design) by Wayne Wolf
5. Embedded Systems - Architecture, Programming and Design by Raj Kamal, McGraw Hill Publishers

## **MCSR240C: Advanced Software Engineering**

### **Unit I: Software Engineering Fundamentals**

Software Process, Software Life Cycle Standards, Software Requirements Analysis & Specification, Software Design.

### **Unit II: Testing**

Testing Fundamentals, System Testing, Integration Testing, Black Box Testing, White Box Testing, Testing Process, Software Maintenance

### **Unit III: Project management**

Process, software configuration process models, requirements change management process, Process management process

### **Unit IV: Effort Estimation**

Function Points, COCOMO, Project scheduling and staffing, Risk Management

### **Unit V: Software metrics and Reliability**

Errors, Faults and Failures, Reliability as a Quality Attribute, Requirements Reliability Metrics, Textual Requirement Analysis, Design and Code Reliability Metrics, Testing Reliability Metrics

For the practical portion, the following points are to be covered:

1. Project based on PERT/CPM
2. SRS to Deployment of model
3. Applying Software Engineering tools for Cloud-based problems

### **Suggested Books**

1. Software Engineering: A Practitioner's Approach by R.S. Pressman, McGraw-Hill
2. Fundamentals of Software Engineering by R. Mall, PHI
3. Software Engineering by I. Sommerville, Addison Wesley
4. Software Engineering for Students by D. Bell, Addison-Wesley

# **MCSR250C: Operation Research and Research Methodology**

## **Part I: Operation Research**

### **Unit I: Introduction**

Definition, Concept, Meaning, Phases, Scope, Advantages, Disadvantages, Mathematical Modeling of Real Life Problems

### **Unit II: Prerequisite to Linear Programming**

Introduction to Linear algebra, Solution of a system of Linear Equations, Linear independence and dependence of vectors, Concept of Basis, Basic Feasible solution, Convex sets, Extreme points, Hyperplanes and Halfspaces, Convex cones, Polyhedral sets and cones

### **Unit III: Linear Programming Problem**

Linear Programming Problem Formulation, solution by Graphical Method, Theory of Simplex Method, Simplex Algorithm, Two phase Method, Charnes-M Method, Degeneracy, Theory of Duality, Dual-simplex method

For the practical portion, LPP exercises are to be carried out.

## **Part II: Research Methodology**

### **Unit IV: Introduction**

Overview of research; Types of Research approaches: fundamental, pure or theoretical research, applied research, evaluation research, survey research; Sources of research problem; Criteria/Characteristics of a good research problem; Scope and objectives of research problem; Formulation of a research problem, identifying variables, constructing hypotheses, errors in selecting a research problem. 2. Research design: Objectives, Strategies, Guidelines for design of experiments. Selecting a study design. 3. Literature survey – Reviewing the literature, Survey using Web of Science, Survey using Scopus, Literature survey writing up, importance of Review of literature.

### **Unit V: Data and Statistics**

Sources of Data, Documentary Sources, Field Sources, Methods of Data Collection. Data analysis – Definition, Types of analysis, Terminology in data analysis, Data Preparation, Classification, and Visualization of data, assessing data and reporting results; Descriptive statistics: Measure of Central Tendency, Measure of Dispersion, Measure of Relation. Modelling skills – Concept, Different modelling approaches 5. Experimental skills, Safety in laboratory. Testing of Hypothesis: Meaning of Hypothesis, Need for Hypothesis, Types of Hypothesis, Sources of Hypothesis, Functions of Hypothesis, Character of Good Hypothesis, Statistical Testing of Hypothesis, One Sample Test, Two Independent Sample Tests

### **Unit VI: Research Ethics**

Ethics in Research, Ethics and Research Process, Importance of Ethics in Research Plagiarism: Introduction of Plagiarism, Dimension of Plagiarism, Detect Plagiarism, Strategies to Minimize Plagiarism.

For the practical portion, the following points are to be covered:

1. Technical writing - LaTeX, Microsoft Word

## **Suggested Books**

1. Operations Research by Kanti Swarup, P.K. Gupta, Man Mohan, Sultan Chand & Sons
2. Schaum's Outline of Operations Research, Richard Bronson and Govindasami Naadimuthu, McGraw-Hill Education
3. Operations Research: An Introduction, Hamady.A. Taha, TMH
4. Research Methodology : Methods And Techniques by C.R. Kothari and Gaurav Garg, New Age International Publishers
5. Research Methodology : Methods And Techniques by R K Jain, Vayu Education of India
6. Research Methodology: Concepts And Cases by Deepak Chawla and Neena Sondhi, Vikas Publishing House

# Semester–III

## **MCSR310C Computer Vision [20(CIA) + 40(T)] + 40(P)**

**Unit 1:** Digital Image formation and low-level processing

Overview and State-of-the-art techniques, Fundamentals of image formation, Transformation: Orthogonal, Euclidean, Affine, Projective etc., Image Enhancement, Restoration, Histogram processing

**Unit 2:** Feature Extraction

Edges-Canny, Line detectors (Hough Transform), Harris-Corners and Hessian Affine, Orientation Histogram, Feature Selection: Principal Component Analysis (PCA)

**Unit 3:** Image Segmentation: Region Growing, Edge Based approaches to segmentation, Graph-Cut, Mean-Shift, MRFs, Texture Segmentation, Object Detection

**Unit 4:** Object Detection and Classification: Feature Based, Deep Learning Based

**Unit 5:** Case Study: Human Iris Location, hole detection, Generalized Hough Transform (GHT), Spatial matched filtering, object location, health, agriculture and biometric application

**LAB:**

OpenCV: Installation and setup, Basic image operations, mathematical operations on images, bitwise operations, image annotations, QR code detection, using mouse, video I/O

## **Suggestedbook**

- "Computer Vision: A Modern Approach", by Forsyth and Ponce
- "Multiple View Geometry in Computer Vision", by Hartley and Zisserman
- Richard Szeliski, Computer Vision: Algorithms and Applications, Springer-Verlag London Limited 2011.
- Computer Vision: A Modern Approach, D. A. Forsyth, J. Ponce, Pearson Education, 2003.
- Richard Hartley and Andrew Zisserman, Multiple View Geometry in Computer Vision, Second Edition, Cambridge University Press, March 2004.
- Christopher M. Bishop; Pattern Recognition and Machine Learning, Springer, 2006
- R.C. Gonzalez and R.E. Woods, Digital Image Processing, Addison- Wesley, 1992.
- K. Fukunaga; Introduction to Statistical Pattern Recognition, Second Edition, Academic Press, Morgan Kaufmann, 1990.

## **MCSR320C Data Warehouse and Mining ([20(CIA) + 40(T)] + 40(P))**

1.1. Overview And Concepts: Need for data warehousing, Basic elements of data warehousing, Trends in data warehousing.

1.2. Planning And Requirements: Project planning and management, Collecting the requirements.

1.3. Architecture And Infrastructure: Architectural components, Infrastructure and metadata.

1.4. Data Design And Data Representation: Principles of dimensional modelling, Dimensional modelling advanced topics, data extraction, transformation and loading, data quality.

1.5. Information Access and Delivery: Matching information to classes of users, OLAP in data warehouse, Data warehousing and the web, Introductory Concept of Hadoop and MapReduce.

1.6. Implementation And Maintenance: Physical design process, data warehouse deployment, growth and maintenance.

**Unit 2: Data Mining:**

2.1. Introduction: Basics of data mining, related concepts, Data mining techniques; Data Mining Algorithms: Classification, Clustering, Association rules; Knowledge Discovery: KDD Process

2.2. Web Mining: Web Content Mining, Web Structure Mining, Web Usage mining, Spatial mining, Temporal mining.

2.3. Visualisation: Data generalization and summarization-based characterization, Analytical characterization: analysis of attribute relevance, Mining class comparisons: Discriminating between different classes, Mining descriptive statistical measures in large databases

2.4. Data Mining Primitives, Languages, and System Architectures: Data mining primitives, Query language, Designing GUI based on a data mining query language, Architectures of data mining systems

2.5. Application and Trends in Data Mining: Applications, Systems products and research prototypes, Additional themes in data mining, Trends in data mining

### **LAB:**

Installation of WEKA Tool; Creating new Arff File; Pre-Processes Techniques on Data Set; Pre-process a given dataset based on Handling Missing Values; Generate Association Rules using the Apriori Algorithm; Generating association rules using fpgrowth algorithm; Build a Decision Tree by using J48 algorithm; Naïve bayes classification on a given data set; Applying k-means clustering on a given data set; Calculating Information gains measures; OLAP Cube and its different operations; Case Study: Create Student.ariff file to suggest better college using Decision tree; Case Study: Create Placement.ariff file to identify the students who are eligible for placements using KNN

### **Suggested Books:**

- Data Mining Concepts and Techniques by Jiawei Han and Micheline Kamber, Morgan Kaufmann Publishers.
- Data Warehousing, Data Mining and OLAP by Berson, Tata McGraw Hill.
- Introduction to Data Mining by Pang-Ning Tan, Michael Steinbach, Vipin Kumar, Pearson Education.
- Data mining: Introductory and Advanced Topics by Dunham M H, Pearson Education.
- Mining Concepts, Methods and Algorithms by Mehmed Kantardzic, John Wiley and Sons.
- Big Data Simplified by Sayan Goswami Sourabh Mukherjee, Amit Kumar Das.

## **MCSR330T Mobile and wireless Computing (20(CIA) + 80(T))**

### Unit 1. Wireless networking

Primer on wireless communications and networking

#### A. Physical layer

- OFDM and 802.11 (WiFi) PHY
- Multi-antenna systems and MIMO
- Overview of 802.11n/ac PHY including beamforming

#### B. MAC layer

- CSMA/CA, CSMA/CD and WiFi MAC overview
- Wide bandwidth channel access techniques (802.11n/ac)
- Energy efficiency and rate control

### Unit 2. Mobile and wearable sensing

#### A. Overview of smartphone/wearable sensors

- Accelerometer, gyroscope, magnetometer etc.
- Smartphone orientation and heading detection

#### B. Activity recognition and healthcare

- Identifying human activities and context through sensors

- Health monitoring and fitness tracking
- C. Wearables overview
  - Wrist-worn wearables - gesture and remote interaction
  - Sensor fusion in body-area networks

### Unit 3. Multi-gigabit wireless networks

Next generation (5G) wireless technologies

Upper Gigahertz and Terahertz wireless communications

- A. Millimeter wave networking
  - Directionality and beamforming
  - Mobility and signal blockage
  - IEEE 802.11ad (60 GHz WLAN) MAC and PHY overview
- B. Visible light communication
  - High-speed networking using LEDs
  - IEEE 802.15.7 PHY and MAC overview
- C. Sensing through visible light
  - Visible light indoor localization and positioning

### Unit 4. Indoor localization and RF sensing

- A. Smartphone localization
  - WiFi fingerprinting - protocols and challenges
  - Non-WiFi localization
- B. Device-free sensing with radio frequency
  - Mining wireless PHY channel state information
  - Device-free localization and indoor human tracking
  - Activity and gesture recognition through RF

### **Suggested Books -**

- Wireless Communications: Principles and Practice, by Theodore S. Rappaport, Prentice Hall.
- 802.11n: A Survival Guide, by Matthew Gast, O'Reilly Media.
- 802.11ac: A Survival Guide, by Matthew Gast, O'Reilly Media.
- Wireless Networking Complete, by Pei Zheng et al., Morgan Kaufmann.

### **MCSR341T Cloud Computing 20(CIA) + 80(T)**

#### UNIT I

Introduction to Cloud Computing- Cloud issues and challenges - Properties - Characteristics - Service models, Deployment models.

#### UNIT II

Cloud resources: Network and API - Virtual and Physical computational resources - Data-storage. Virtualization concepts - Types of Virtualization- Introduction to Various Hypervisors - High Availability (HA)/Disaster Recovery (DR) using Virtualization, Moving VMs .

#### UNIT III

Service models - Infrastructure as a Service (IaaS) - Resource Virtualization: Server, Storage, Network - Case studies. Platform as a Service (PaaS) - Cloud platform & Management: Computation, Storage - Case studies. Software as a Service (SaaS) - Web services - Web 2.0 - Web OS - Case studies – Anything as a service (XaaS).

## UNIT IV

Cloud Programming and Software Environments – Parallel and Distributed Programming paradigms – Programming on Amazon AWS and Microsoft Azure – Programming support of Google App Engine – Emerging Cloud software Environment.

## UNIT V

Cloud Access: authentication, authorization and accounting - Cloud Provenance and meta-data - Cloud Reliability and fault-tolerance - Cloud Security, privacy, policy and compliance- Cloud federation, interoperability and standards.

### **Suggested Books:**

- Cloud Computing: Principles and Paradigms, Editors: Rajkumar Buyya, James Broberg, Andrzej M. Goscinski, Wiley,2011
- Enterprise Cloud Computing - Technology, Architecture, Applications, Gautam Shroff, Cambridge University Press, 2010
- Cloud Computing Bible, Barrie Sosinsky, Wiley-India, 2010
- Cloud Security: A Comprehensive Guide to Secure Cloud Computing, Ronald L. Krutz, Russell Dean Vines, Wiley- India,2010

## **MCSR351T Network Security 20(CIA) + 80(T)**

### UNIT-I

Security Attacks (Interruption, Interception, Modification and Fabrication), Security Services(Confidentiality, Authentication, Integrity, Non-repudiation, access Control and Availability) and Mechanisms, A model for Internetwork security, Internet Standards and RFCs, Buffer overflow & formatstring vulnerabilities, TCP session hijacking, ARP attacks, route table modification, UDP hijacking, and man-in-the-middle attacks.

### UNIT-II

Conventional Encryption Principles, Conventional encryption algorithms, cipher block modes of operation, location of encryption devices, key distribution Approaches of Message Authentication, Secure Hash Functions and HMAC.

### UNIT-III

Public key cryptography principles, public key cryptography algorithms, digital signatures, digital Certificates, Certificate Authority and key management Kerberos, X.509 Directory Authentication Service.

### UNIT-IV

Email privacy: Pretty Good Privacy (PGP) and S/MIME. IP Security Overview, IP Security Architecture, Authentication Header, Encapsulating Security Payload, Combining Security Associations and Key Management.

### UNIT-V

Basic concepts of SNMP, SNMPv1 Community facility and SNMPv3. Intruders, Viruses and related threats. Firewall Design principles, Trusted Systems. Intrusion Detection Systems.

### **Suggested Books**

- Network Security Essentials (Applications and Standards) by William Stallings Pearson Education.
- Hack Proofing your network by Ryan Russell, Dan Kaminsky, Rain Forest Puppy, JoeGrand, David Ahmad, Hal Flynn Ido Dubrawsky, Steve W.Manzuik and Ryan Permeah, Wiley Dreamtech
- Network Security and Cryptography: Bernard Menezes, CENGAGE Learning.
- Network Security - Private Communication in a Public World by CharlienKaufman, Radia Perlmanand Mike Speciner, Pearson/PHI.
- Cryptography and network Security, Third edition, Stallings, PHI/Pearson
- Principles of Information Security, Whitman, Cengage Learning.

### **MCSR342T Business Intelligence 20(CIA) + 80(T)**

#### Unit I: Introduction to Business Intelligence

Understanding the scope of today's BI solutions and how they fit into existing infrastructure Assessing new options such as SaaS and cloud-based technology. Describe BI, its components & architecture, previewing the future of BI Crafting a better experience for all business users, End User Assumptions, Setting up Data for BI, The Functional Area of BI Tools, Query Tools and Reporting, OLAP and Advanced Analytics, Supporting the requirements of senior executives, including performance management.

#### Unit II: Elements of Business Intelligence Solutions

Reports & ad hoc queries; Analyse OLAP data; Dashboards & Scorecards development, Metadata Models; Automated tasks & events; Mobile & disconnected BI; Collaboration capabilities; Real time monitoring capabilities; Software development kit; Consume BI through portals, web applications, Desktop applications.

#### Unit III: Building the BI Project

Planning the BI project, Project Resources; Project Tasks, Risk Management and Mitigation, Cost-justifying BI solutions and measuring success, Collecting User Requirements, Requirements-Gathering Techniques; Prioritizing & Validating BI Requirements, Changing Requirements; BI Design and Development, Best Practices for BI Design; Post-Implementation Evaluations, Maintaining Your BI Environment.

#### Unit IV: Reporting authoring

Building reports with relational vs Multidimensional data models; Types of Reports – List, crosstabs, Statistics, Chart, map, financial etc; Data Grouping & Sorting, Filtering Reports, Adding Calculations to Reports, Conditional formatting, Adding Summary Lines to Reports. Drill up, drill- down, drill-through capabilities. Run or schedule report, different output forms – PDF, excel, csv, xml etc.

#### Unit V: BI Deployment, Administration & Security

Centralized Versus Decentralized Architecture, BI Architecture Alternatives, phased & incremental BI roadmap, System Sizing, Measurements and Dependencies, System Sizing, Measurements, and Dependencies. Setting Early Expectations and Measuring the Results. End-User Provisos. OLAP Implementations. Expanding BI Authentication Authorization, Access Permissions, Groups and Roles, Single-sign on Server Administration, Manage Status & Monitoring, Audit, Mail server & Portal integration, Back Up and Restore.

#### **Suggested Books–**

- Business Intelligence (IBM ICE Publication).

### **MCSR352T Deep Learning 20(CIA) + 80(T)**

#### UNIT I DEEP LEARNING CONCEPTS



Fundamentals about Deep Learning. Perception Learning Algorithms. Probabilistic modelling. Early Neural Networks. How Deep Learning different from Machine Learning. Scalars. Vectors. Matrixes, Higher Dimensional Tensors. Manipulating Tensors. Vector Data. Time Series Data. Image Data. Video Data.

## UNIT II NEURAL NETWORKS

About Neural Network. Building Blocks of Neural Network. Optimizers. Activation Functions. Loss Functions. Data Pre-processing for neural networks, Feature Engineering. Overfitting and Underfitting. Hyperparameters.

## UNIT III CONVOLUTIONAL NEURAL NETWORK

About CNN. Linear Time Invariant. Image Processing Filtering. Building a convolutional neural network. Input Layers, Convolution Layers. Pooling Layers. Dense Layers. Backpropagation Through the Convolutional Layer. Filters and Feature Maps. Backpropagation Through the Pooling Layers. Dropout Layers and Regularization. Batch Normalization. Various Activation Functions. Various Optimizers. LeNet, AlexNet, VGG16, ResNet. Transfer Learning with Image Data. Transfer Learning using Inception Oxford VGG Model, Google Inception Model, Microsoft ResNet Model. RCNN, Fast R-CNN, Faster R-CNN, Mask-RCNN, YOLO

## UNIT IV NATURAL LANGUAGE PROCESSING USING RNN

About NLP & its Toolkits. Language Modeling . Vector Space Model (VSM). Continuous Bag of Words (CBOW). Skip-Gram Model for Word Embedding. Part of Speech (PoS) Global Cooccurrence Statistics-based Word Vectors. Transfer Learning. Word2Vec. Global Vectors for Word Representation GloVe. Backpropagation Through Time. Bidirectional RNNs (BRNN). Long Short Term Memory (LSTM). Bidirectional LSTM. Sequence-to-Sequence Models (Seq2Seq). Gated recurrent unit GRU.

## UNIT V DEEP REINFORCEMENT & UNSUPERVISED LEARNING

About Deep Reinforcement Learning. Q-Learning. Deep Q-Network (DQN). Policy Gradient Methods. Actor-Critic Algorithm. About Autoencoding. Convolutional Auto Encoding. Variational Auto Encoding. Generative Adversarial Networks. Autoencoders for Feature Extraction. AutoEncoders for Classification. Denoising Autoencoders. Sparse Autoencoders

## LIST OF EXPERIMENTS:

- 1: Feature Selection from Video and Image Data
- 2: Image and video recognition
- 3: Image Colorization
- 4: Aspect Oriented Topic Detection & Sentiment Analysis
- 5: Object Detection using Autoencoder

## Suggested Books

- Deep Learning A Practitioner's Approach Josh Patterson and Adam Gibson O'Reilly Media, Inc.2017
- Learn Keras for Deep Neural Networks, Jojo Moolayil, Apress, 2018
- Deep Learning Projects Using TensorFlow 2, Vinita Silaparasetty, Apress, 2020
- Deep Learning with Python, FRANÇOIS CHOLLET, MANNING SHELTER ISLAND, 2017
- Pro Deep Learning with TensorFlow, Santanu Pattanayak, Apress, 2017

# Semester–IV

## **MCSR411T Security for Business Infrastructure, Cyber Law and Ethics (20(CIA) + 80(T))**

Unit 1: Security Awareness, Compliance, Assessments, and Risk : Social Engineering, Phishing, Security Awareness, Security Assessment and Audit, What is GRC?, NIST Framework Overview, PCI-DSS Framework Overview, Challenges of Compliance versus Security

Unit 2: Hybrid Cloud Security Enterprise Shift to Hybrid Cloud, Workload Micro-Segmentation, Defense in Depth through Micro-Segmentation, Cloud Access Security Brokers, Advanced Hybrid Cloud Security Architecture , Security of Isolated Servers

Unit 3: Introduction to Cyber security Defining Cyberspace and Overview of Computer and Web-technology, Architecture of cyberspace, Communication and web technology, Internet, World wide web, Advent of internet, Internet infrastructure for data transfer and governance, Internet society, Regulation of cyberspace, Concept of cyber security, Issues and challenges of cyber security

Unit 4: Cyber crime and Cyber law Classification of cyber crimes, Common cyber crimes- cyber crime targeting computers and mobiles, cyber crime against women and children, financial frauds, social engineering attacks, malware and ransomware attacks, zero day and zero click attacks, Cybercriminals modus-operandi , Reporting of cyber crimes, Remedial and mitigation measures, Legal perspective of cyber crime, IT Act 2000 and its amendments, Cyber crime and offences, Organizations dealing with Cyber crime and Cyber security in India, Case studies

Unit 5: Blockchain, Anonymity, and Critical Infrastructure Protection: Blockchain, Cyber Attribution Onion Routing and Tor Chaum Binding Algorithm

### **Suggested Books:**

- Cyber Security and IT Infrastructure Protection, John R. Vacca, Syngress Publisher, O'Reilley
- Cyber Law and Ethics: Regulation of the Connected World, Eric P. Robinson and Mark Grabowski, Routledge; 1st edition

## **MCSR421T Security for Cyber-Physical Systems (20(CIA) + 80(T))**

Introduction: Cyber-Physical System (CPS), Key Features of CPS, Application Domains of CPS, Basic principles of design and validation of CPS, Challenges in CPS.

CPS Platform components: CPS HW platforms, Processors, Sensors and Actuators, CPS Network -Wireless, CAN, Automotive Ethernet, Scheduling Real Time CPS tasks, Synchronous Model and Asynchronous Model.

Synchronous and Asynchronous Model: Reactive Components, Components Properties, Components Composing, Synchronous Designs and Circuits, Asynchronous Processes and operations, Design Primitives in Asynchronous Process, Coordination Protocols in Asynchronous Process, Leader Election, Reliable Transmission. Security of Cyber-Physical Systems: Introduction to CPS Securities, Basic Techniques in CPS Securities, Cyber Security Requirements, Attack Model and Countermeasures, advanced Techniques in CPS Securities.

CPS Application: Health care and Medical Cyber-Physical Systems, Smart grid and Energy CyberPhysical

Systems, WSN based Cyber-Physical Systems, Smart Cities.

**Suggested Books:**

- E. A. Lee and S. A. Seshia, "Introduction to Embedded Systems: A Cyber-Physical Systems Approach", 2011.
- R. Alur, "Principles of Cyber-Physical Systems," MIT Press, 2015.
- Raj Rajkumar, Dionisio de Niz and Mark Klein, "Cyber-Physical Systems", Addison-Wesley, 2017
- Rajeev Alur, "Principles of Cyber-Physical Systems", MIT Press, 2015
- Fei Hu, "Cyber-Physical Systems", CRC Press 2013

**MCSR431T IOT and Smart Systems20(CIA) + 80(T)**

Unit I: Introduction to IoT

Brief History and evolution of IoT, Definition of IoT, Characteristics of IoT, Physical design of IoT, Logical design of IoT, Functional blocks of IoT. Communication models and APIs.

Unit II: IoT & Machine to Machine

Machine to Machine, Difference between IoT and M2M, Software define Network, SDN and NFV for IoTs.

Unit III: Challenges in IoT

IoT Services Platform: Functions and Requirements, Design challenges, Development challenges, Internet of Things Security and Privacy, Other challenges.

Unit IV: Developing IoTs Introduction to Python and IoT tools, Developing applications through IoT tools, Developing sensor based application through IoT platform.

Unit V: Specific applications of IoT

IOT for Home automation, Smart Cities, Environment monitoring, IOT for financial inclusion, Logistics monitoring, IOT for rural empowerment, Industry applications, Health monitoring, Other IoT applications.

**Suggested Books:**

- Machine Learning and IoT for Intelligent Systems and Smart Applications, Madhumathy P, M Kumar, R. Umamaheswari, CRC Press
- IoT Fundamentals: Networking Technologies Protocols And Use Cases For The Internet Of Things, Hanes David, Salgueiro Gonzalo, Grossetete Patrick, Barton Rob, Henry Jerome, Pearson Education; First Edition
- IoT for Beginners: Explore IoT Architecture, Working Principles, IoT Devices, and Various Real IoT Projects, Vibha Soni, BPB Publications

**MCSR412T Bioinformatics 20(CIA) + 80(T)**

Basic Biology: What is life? The unity and the diversity of living things. Prokaryotes and Eukaryotes, Yeast and People, Evolutionary time and relatedness, Living parts: Tissues, cells, compartments and organelles, Central dogma of molecular biology, Concept of DNA, RNA, Protein and metabolic pathway. What is Bioinformatics? Recent challenges in Bioinformatics.

Biological databases: Their needs and challenges. Example of different biological databases – sequence, structure, function, micro-array, pathway, etc.

Sequence Analysis: Theory and Tools: Pairwise alignment – Different local and global search alignment, Heuristic searches (like BLAST) applicable to search against database, Multiple alignment algorithms, Whole genome comparison.

Walk through the genome: Prediction of regulatory motifs, Operon, Gene, splices site, etc.

Markov models: Hidden Markov models – The evaluation, decoding and estimation problem and the algorithms. Application in sequence analysis.

Molecular phylogeny: maximum Parsimony, distance Matrix and maximum likelihood methods. Concepts of adaptive evolution.

Application of graph theory in Biology: Biochemical Pathway, Protein-protein interaction network, Regulatory network and their analysis.

**Suggested Books:**

- Bioinformatics: David Mount
- Biological Sequence Analysis: Probabilistic Models of Proteins and Nucleic acids, R. Durbin, S.R. Eddy, A. Krogh and G. Mitchison.

**MCSR422T NLP and Text Analytics 20(CIA) + 80(T)**

Unit 1: NLP

Word Embeddings, Deep learning models for NLP , Recurrent networks, LSTM , Attention models, transformers, POS tagging, Entity tagging, Topic Categorization, Opinion analysis, Grammars and Parsing, Information Extraction (relationship, event extraction), Summarization, Entity resolution, wikification, Trending phrases, terminology discovery, Semantic Role Labeling, Textual Entailment

Unit 2: Recommender Systems

Collaborative filtering, Model based, content based

Unit 3: Social Network Analysis

Network models and measures, Diffusion models, Influence Models, Behaviour analytics

**Suggested books:**

- Speech and Language Processing (3rd Edition) Daniel Jurafsky and James Martin, 2019. [SLP]
- Recommender Systems Charu C. Aggarwal, Springer, 2016. [RS]
- Social Media Mining Zafarni, Abbasi and Liu, Cambridge University Press, 2014. [SMM]

**MCSR432T Social Network Analytics 20(CIA) + 80(T)**

UNIT 1 – Social Network Analysis: Preliminaries and definitions, Erdos Number Project, Centrality measures, Balance and Homophily.

UNIT 2 – Random graph models: Random graphs and alternative models, Models of network growth, Navigation in social Networks, Cohesive subgroups, Multidimensional Scaling, Structural equivalence, roles and positions.

Unit 3 – Network topology and diffusion, Contagion in Networks, Complex contagion, Percolation and information, Navigation in Networks Revisited.

UNIT 4 – Small world experiments, small world models, origins of small world, Heavy tails, Small Diameter, Clustering of connectivity, The ErdosRenyi Model, Clustering Models.

UNIT 5 – Network structure -Important vertices and page rank algorithm, towards rational dynamics in networks, basics of game theory, Coloring and consensus, biased voting, network formation games, network structure and equilibrium, behavioral experiments, Spatial and agent-based models.

**Suggested Books:**

- S. Wasserman and K. Faust. “Social Network Analysis: Methods and Applications”, Cambridge University Press.
- D. Easley and J. Kleinberg, “Networks, Crowds and Markets: Reasoning about a highly connected world”, Cambridge University Press, 1st edition,2010
- Maarten van Steen. “Graph Theory and Complex Networks. An Introduction”, 2010.2)RezaZafarani, Mohammed Ali Abbasi, Huan Liu. “Social Media Mining: An Introduction”. Cambridge University Press 2014.
- Maksim Tsvetovat and Alexander Kouznetsov. “Social Network Analysis for Startups”. O’Reilly Media, 2011.